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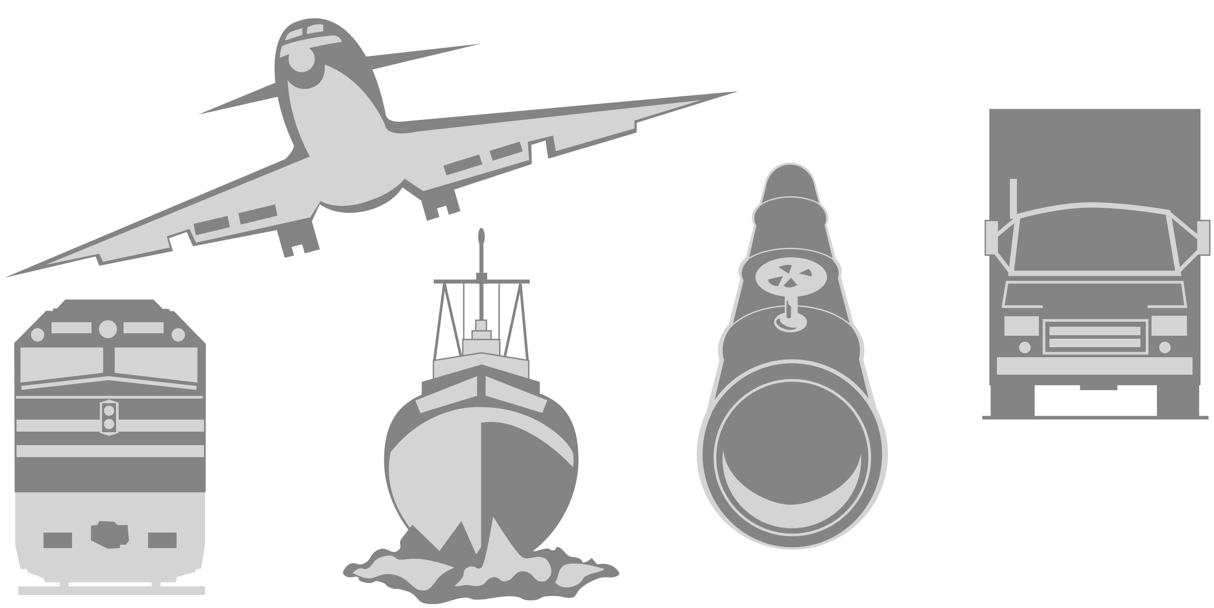
NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

SAFETY RECOMMENDATIONS

ADOPTED MARCH 2002



National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: March 12, 2001

In reply to refer to: R-01-03, I-01-01, and I-00-06 (Reiteration)

Mr. Edward A. Brigham
Acting Deputy Administrator
Research and Special Programs Administration
400 Seventh Street, S.W.
Washington, D.C. 20590

About 12:05 a.m. on February 18, 1999, railroad tank car UTLX 643593, which was on the west unloading rack at the Essroc Cement Corporation cement plant near Clymers, Indiana, sustained a sudden and catastrophic rupture that propelled the tank car's tank about 750 feet and over multistory storage tanks.[1] There were no injuries or fatalities. Total damages, including property damage and costs from lost production, were estimated at nearly $8.2 million. The National Transportation Safety Board determined that the probable cause of the accident was the failure of Essroc Cement Corporation (Essroc) and CP Recycling of Indiana management to develop and implement safe procedures for offloading toluene diisocyanate (TDI) matter wastes, resulting in the overpressurization of the tank car from chemical self-reaction and expansion of the TDI matter wastes.

The catastrophic rupture of UTLX 643593 is the fifth nonaviation accident investigated by the Safety Board since June 1998 in which deficient offloading procedures or operations caused or contributed to an accident and the release of hazardous materials. The first of the five accidents took place on June 29, 1998, at Stock Island, Key West, Florida.[2] A Dion Oil Company driver was on top of a straight-truck cargo tank checking its contents and preparing to transfer cargo from a semitrailer cargo tank when explosive vapors ignited within the straight-truck cargo tank. The ignition caused an explosion that threw the driver from the truck. The fire and a series of at least three explosions injured the driver and destroyed the straight truck, a tractor, the front of the semitrailer, and a second nearby straight-truck cargo tank. Damage was estimated at more than $185,000.

The Safety Board concluded from its investigation that (1) the carrier did not have written procedures to ensure safe cargo handling, (2) the carrier did not adequately train its drivers to

[1] For more information, see forthcoming Hazardous Materials Accident Report NTSB/HZM-01/01: *Catastrophic Rupture of a Railroad Tank Car Containing Hazardous Waste Near Clymers, Indiana, February 18, 1999* (Washington, DC: National Transportation Safety Board, 2001).

[2] National Transportation Safety Board, *Fire and Explosion of Highway Cargo Tanks, Stock Island, Key West, Florida, June 29, 1998*, Hazardous Materials Accident Report NTSB/HZM-99/01 (Washington, DC: NTSB, 1999).

ensure safe cargo handling, and (3) Federal training programs for Federal and State motor carrier inspectors did not adequately address the need for inspectors to evaluate the training that motor carriers give their drivers on loading and unloading cargo tanks. Consequently, the Safety Board recommended on October 1, 1999, that the Federal Highway Administration's (FHWA's) Office of Motor Carrier Safety (now the Federal Motor Carrier Safety Administration [FMCSA]):[3]

> H-99-30
>
> Add elements to training programs for Federal and State inspectors that include instruction on determining whether motor carriers have adequate written procedures for and driver training in loading and unloading cargo tanks.
>
> H-99-31
>
> Evaluate the adequacy of cargo-tank loading and unloading procedures of and driver training for hazardous-materials motor carriers and require changes as appropriate.

To date, the Safety Board has not received a response to either recommendation from the FMCSA. On December 14, 2000, the Safety Board sent a follow-up letter to the FMCSA requesting an update on the status of these two recommendations.

Another accident concerning a transfer of hazardous materials took place on August 9, 1998, in Biloxi, Mississippi.[4] A truckdriver was transferring gasoline from a highway cargo tank to underground storage tanks at a gasoline station-convenience store when an underground storage tank containing gasoline overflowed. An estimated 550 gallons of gasoline flowed from the storage tank, across the station lot, and into the adjacent highway and intersection. The gasoline ignited, and fire engulfed three vehicles near the intersection. Five occupants of the vehicles were killed, and one occupant was seriously injured. Property damages were estimated at $55,000.

As a result of its Biloxi investigation, the Safety Board concluded that the carrier's operating manuals for its new employees and driver-trainers lacked the specificity that employees need to ensure that they practice correct and safe cargo unloading procedures. The Safety Board also concluded that to help drivers follow safe loading and unloading procedures, Federal regulations should require carriers that transport hazardous materials in cargo tanks to have specific, written procedures for loading and unloading. Consequently, the Safety Board recommended that the Research and Special Programs Administration (RSPA):

> H-99-57
>
> Promulgate regulations requiring motor carriers that transport hazardous materials in cargo tanks to develop and maintain specific written cargo loading and unloading procedures for their drivers.

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[3] The December 9, 1999, enactment of the Motor Carrier Safety Improvement Act of 1999 established a new U.S. Department of Transportation (DOT) agency, the FMCSA, to oversee and enforce motor carrier safety regulations, which had previously been handled by the FHWA.

[4] National Transportation Safety Board, *Overflow of Gasoline and Fire at a Service Station-Convenience Store, Biloxi, Mississippi, August 9, 1998,* Hazardous Materials Accident Report NTSB/HZM-99/02 (Washington, DC: NTSB, 1999).

In a February 24, 2000, response to Safety Recommendation H-99-57, RSPA stated it is evaluating options to amend the general training requirements and the current specialized requirements for motor carriers in the DOT *Hazardous Materials Regulations*. On April 4, 2000, the Safety Board classified Safety Recommendation H-99-57 "Open–Acceptable Response," pending RSPA's development of regulations that meet the intent of the recommendation. On January 5, 2001, the Safety Board sent a letter to RSPA requesting an update on the actions RSPA has taken on this recommendation since February 2000.

Following the Biloxi accident, the Safety Board also recommended that the FHWA:

<u>H-99-59</u>

> Once the Federal regulations requiring motor carriers that transport hazardous materials in cargo tanks to provide written cargo loading and unloading procedures are promulgated, ensure that the motor carriers are in compliance with the regulations.

The FHWA's Office of Motor Carrier Safety stated in a November 23, 1999, response to Safety Recommendation H-99-59 that it would develop procedures to ensure that motor carriers comply with regulations promulgated to address Safety Recommendation H-99-57. The Safety Board classified Safety Recommendation H-99-59 "Open–Acceptable Response" on February 22, 2000. On January 10, 2001, the Safety Board sent a letter to the FHWA requesting an update on the actions taken on this recommendation since February 2000.

On November 19, 1998, at the Ford Motor Company truck plant in Louisville, Kentucky, a cargo tank truck arrived with a delivery of a liquid mixture of nickel nitrate and phosphoric acid. A plant employee inadvertently connected the truck's transfer hose to the wrong connection and then departed the area, leaving the truckdriver to complete the delivery alone. The truckdriver did not check that the connection was correct and began unloading the product into a storage tank that contained a chemically incompatible material. The resulting chemical reaction generated a vapor cloud of toxic gases that forced the evacuation of 2,400 plant employees and caused $192,000 in damages.[5] Another transfer-related accident occurred in Whitehall, Michigan, on June 4, 1999, after a cargo tank truck arrived at the Whitehall Leather Company with a delivery of sodium hydrosulfide solution. At the direction of a Whitehall shift supervisor, the truckdriver connected the transfer hose from the cargo tank truck to the wrong storage tank; the tank contained a chemical that reacted with the solution in the cargo tank truck. The resulting chemical reaction released hydrogen sulfide gas that resulted in the death of the truckdriver and $411,000 in damages.[6]

The Safety Board's investigation of both the Louisville and Whitehall accidents showed that the companies had significant problems with their loading and unloading processes for hazardous materials. The Whitehall Leather Company did not have written instructions and procedures for unloading hazardous materials from bulk cargo tanks and did not have a training program for those employees who might be involved in loading and unloading such materials. The Ford Motor

[5] National Transportation Safety Board, *Chemical Reaction During Cargo Transfer, Louisville, Kentucky, November 19, 1998*, Hazardous Materials Accident Brief HZB/00/02 (Washington, DC: NTSB, 2000).

[6] National Transportation Safety Board, *Chemical Reaction During Cargo Transfer, Whitehall, Michigan, June 4, 1999*, Hazardous Materials Accident Brief HZB/00/03 (Washington, DC: NTSB, 2000).

Company had written instructions and procedures for unloading hazardous materials and maintained a training program on these procedures, but Ford failed to provide the plant employee involved in the Louisville accident with the latest unloading instructions for hazardous materials, which might have prevented the accident.

As a result of its investigations of the Louisville and Whitehall accidents, the Safety Board determined that safety requirements were needed for loading and unloading hazardous materials involved in transport and recommended on June 29, 2000, that RSPA:

> I-00-06
>
> Within 1 year of the issuance of this safety recommendation, complete rulemaking on Docket HM-223, "Applicability of the *Hazardous Materials Regulations* to Loading, Unloading, and Storage," to establish, for all modes of transportation, safety requirements for loading and unloading hazardous materials.

In its July 21, 2000, response to Safety Recommendation I-00-06, RSPA stated that it is drafting a notice of proposed rulemaking (NPRM) under Docket HM-223 and expects to publish the NPRM in early 2001. RSPA anticipates issuance of a final rule by the end of 2001. The Safety Board wrote to RSPA on September 25, 2000, indicating its concern over the slow progress of the rulemaking and urging that a final rule be issued by July 2001. In light of the continuing slow pace of action on this important safety issue indicated by RSPA's letter, the Safety Board classified Safety Recommendation I-00-06 "Open–Unacceptable Response."

The rupture of UTLX 643593 at the Essroc cement plant near Clymers and the accidents in Stock Island, Biloxi, Louisville, and Whitehall can all be attributed to deficient unloading operations that occurred because of inadequate training, or a lack of comprehensive, specific, and written unloading procedures, or both. In the Clymers accident, the failure of the producer/shippers and end-users to collaborate in the development and implementation of comprehensive, written loading and offloading procedures, customized to the characteristics of the TDI matter wastes and the specific facility, resulted in the use of unsafe unloading practices that ultimately caused the tank car to rupture.

Although the DOT *Hazardous Materials Regulations* include general and mode-specific requirements about the loading and unloading of bulk containers such as tank cars, highway cargo tanks, and intermodal tanks, the current requirements only address procedures common to most loading and offloading operations, such as which personnel must attend the transfer, when brakes must be set on the tank car, when tank car wheels must be blocked, and when and how warning signs must be placed. The DOT *Hazardous Materials Regulations* do not include requirements for loading and unloading procedures to be written based on any unique or particular properties of the hazardous materials that would necessitate the implementation of special handling requirements or on the conditions specific to an individual facility. As demonstrated in the Clymers accident, the use of unloading practices that are not based on such thorough and comprehensive standards can have catastrophic consequences. Therefore, the Safety Board concluded that the DOT *Hazardous Materials Regulations* are deficient because they fail to require the development and implementation of comprehensive, written loading and unloading procedures for hazardous materials.

The Stock Island, Biloxi, Louisville, Whitehall, and Clymers accidents all involved the loading and unloading of transport containers carrying hazardous materials. Of the five accidents, however, only the Clymers accident involved rail rather than motor carrier transportation. Recently, therefore, the Safety Board's safety recommendations concerning loading and unloading regulations have focused primarily on highway transportation. The Clymers accident, however, showed that swift action is needed to improve the safety of hazardous material loading and unloading operations involving rail tank cars as well as highway cargo tanks. Therefore, to ensure that loading and unloading safety provisions are equivalent throughout transportation modes, the Safety Board considers that action is needed to address the deficiencies in the loading and unloading regulations for rail transport of hazardous materials. Such multimodal action is implicit in Safety Recommendation I-00-06, which the Safety Board issued following the Whitehall and Louisville accidents, which called for RSPA "to establish, *for all modes of transportation*, safety requirements for loading and unloading hazardous materials." (Emphasis added)

Despite the need to carry out this recommendation promptly, as evidenced by the Stock Island, Biloxi, Louisville, Whitehall, and Clymers accidents, RSPA has not yet completed action on it or indicated that RSPA intends to accomplish the recommendation before the end of 2001. The Safety Board is concerned that such slow progress on Safety Recommendation I-00-06 could negatively affect the safety of hazardous materials transportation in all modes. Therefore, to ensure that comprehensive, written safety requirements are established without delay for all carriers, including rail carriers, that transport hazardous materials in cargo tanks, the Safety Board reiterates Safety Recommendation I-00-06.

Among other issues raised by the investigation of the Clymers accident was the adequacy of inspection and testing requirements for pressure relief devices on railroad tank cars. After the Clymers accident, the Federal Railroad Administration (FRA) mandated that the pressure relief valves from 4 of 24 tank cars containing TDI matter wastes in storage near Clymers be pressure-tested in accordance with the DOT *Hazardous Materials Regulations* before any of the tank cars could be transported for unloading. When these tests were performed in March 1999, three of the four valves were not due for retesting until 2003. Each valve had 4 years remaining of its 10-year test cycle. The fourth valve, also on a 10-year test cycle, was due for a retest in 1999. The pressure relief valve from UTLX 643593 was on a 10-year test cycle and not due for a retest until 2003. This valve was also examined and tested in May 1999. All five pressure relief valves failed to meet the tolerances for the start-to-discharge pressure and vapor-tight pressure as required under the regulations.

The teardown and inspection of the pressure relief valves from these five tank cars (the four cars that the FRA required to be tested and UTLX 643593) demonstrated that the valves were in a deteriorated condition. The ethylene propylene rubber O-rings showed evidence of swelling, hardness, and brittleness, and the metallic components exhibited varying degrees of rust, scale, pitting, and grit. Replacement of the deteriorated O-rings in the pressure relief valve from UTLX 643593 with new O-rings did not, by itself, bring about proper operation of the valve. Even with the new O-rings, the pressure relief valve from UTLX 643953 was within the tolerances for the start-to-discharge and vapor-tight pressures only after all dirt, grit, and other debris had been removed from the sealing surfaces of the valve. Consequently, it appears that the accumulation of rust, scale, and dirt caused the five pressure relief valves to fail to meet the required start-to-discharge and vapor-pressure standards. Therefore, the Safety Board concluded that, based on the deteriorated condition of the pressure relief valves examined in this investigation and the failure of these valves to activate as required, the pressure relief valves on tank cars that transport hazardous materials may require more frequent and rigorous testing to ensure that they remain functional.

The testing interval for a tank car and its components under the DOT *Hazardous Materials Regulations* depends in part upon the types of products that are transported in the tank car. Tank cars that transport corrosive materials must be inspected and retested every 5 to 10 years, whereas tank cars that transport noncorrosive materials must be inspected and retested every 10 years. The regulations also require testing and inspection if there is evidence of damage, corrosion, cracks, dents, or deformation or if the tank car is involved in an accident and is repaired. However, the deterioration of the pressure relief valves from UTLX 643593 and the other four tank cars was only detected when the valves were disassembled and inspected. The Safety Board believes that RSPA and the FRA should, with the assistance of the Association of American Railroads and the Railway Progress Institute, evaluate the deterioration of pressure relief devices through normal service and then develop inspection criteria to ensure that the pressure relief devices remain functional between regular inspection intervals. They should also incorporate these inspection criteria into the DOT *Hazardous Materials Regulations*.

A third issue that the Safety Board pursued during the Clymers accident investigation was the adequacy of the DOT *Hazardous Materials Regulations* pertaining to the notification and reporting of hazardous materials incidents. When the Clymers accident occurred, the Essroc plant manager immediately notified the National Response Center (NRC) by telephone, in compliance with Federal regulations, about the releases of hazardous wastes. According to 40 *Code of Federal Regulations* 264.56(j) the owner/operator of a transfer, storage, and disposal (TSD) facility that experiences a hazardous waste incident must also submit a written report to the Environmental Protection Agency (EPA) regional administrator within 15 days of the incident. Essroc sent a report concerning the Clymers accident to the EPA Region 5 office on March 4, 1999. However, neither the written report to the EPA required under 40 *Code of Federal Regulations* 264.56(j) nor the immediate telephone report to the NRC comprise the high level of detail regarding a hazardous materials incident reflected in the DOT Hazardous Materials Incident Report form. Neither would contain, as would the DOT Hazardous Materials Incident Report, detailed information concerning the container and packaging used to transport the hazardous material, the specific circumstances of the failure, or the transportation environment in which the incident occurred. Consequently, neither could provide the in-depth information that RSPA needs to maintain its Hazardous Materials Information System, which is crucial to RSPA's ability to carry out meaningful analyses of reported accident data.

The requirements in 49 *Code of Federal Regulations* 171.16 of the DOT *Hazardous Materials Regulations* place the responsibility for submitting the written DOT Hazardous Materials Incident Report on the carrier. The requirements apply to releases of hazardous materials that occur during the course of transportation, which has been defined under 49 *United States Code* Section 5102 to include "the movement of property and the loading, unloading, or storage incidental to the movement."

In the case of the Clymers accident, it seems reasonable that the Central Railroad of Indianapolis, the carrier that delivered UTLX 643593 and other tank cars carrying TDI waste mixtures to the Essroc plant, assumed it was not responsible for filing a written DOT Hazardous Materials Incident Report with RSPA. The railroad had delivered the tank car to the Essroc plant on December 7, 1998, more than 2 months before the accident took place. The accident occurred on the plant property, and the railroad was not involved in the accident. The Central Railroad of Indianapolis thus had good reason to suppose it was no longer responsible for filing a written report with RSPA. Essroc likewise did not provide a DOT Hazardous Materials Incident Report to RSPA because it is a TSD facility operator, not a carrier.

Consequently, no DOT Hazardous Materials Incident Report was filed for this accident with RSPA, even though a DOT specification tank car used in revenue service and containing a regulated hazardous waste catastrophically ruptured. The Safety Board concluded that, because the requirements of 49 *Code of Federal Regulations* 171.16 place the responsibility for filing the written DOT Hazardous Materials Incident Report solely upon the carrier, the current requirements do not ensure that RSPA receives the information the Safety Board believes it needs to develop safe practices.

Of the parties involved, the carrier is least likely to have knowledge of or be involved in an accident or incident that occurs at a shipper or consignee facility where loading and unloading operations are carried out, and where hazardous materials containers are temporarily stored. As a result, many loading and unloading accidents may not be reported to the DOT.

The written DOT Hazardous Materials Incident Reports provide the input for the Hazardous Materials Information System, which is RSPA's accident database. Because this database is used (among other things) to carry out trend analyses, the failure to capture data about incidents at loading and offloading facilities may skew accident analyses conducted using these data and obscure industry performance and operational deficiencies. Further, the Safety Board's review of EPA regulations demonstrated that the comprehensive data required are collected only by the written DOT Hazardous Materials Incident Reports.

The Safety Board has previously expressed its concern about this issue to RSPA, most recently through its July 26, 1999, comments on the March 23, 1999, advance notice of proposed rulemaking that RSPA issued on revising the incident reporting requirements and the DOT Hazardous Materials Incident Report form. Citing reporting deficiencies identified in the Clymers, Louisville, and Biloxi hazardous materials accidents, the Safety Board noted that when accidents involving releases of hazardous materials from DOT specification containers occur at loading or unloading facilities, a carrier may not be directly involved, increasing the likelihood that such accidents will go unreported to RSPA. The Safety Board stated that it believed that "…a complete and accurate accident database requires that incident reports be filed for any failure of hazardous material containers or the unintended release of a hazardous material during any transportation-related operation…."

To repair this gap in the notification and reporting standards, the Safety Board believes that RSPA should take action to ensure that comprehensive reports concerning all significant failures of DOT specification tank cars, highway cargo tanks, and intermodal bulk containers containing hazardous materials are provided in writing to RSPA.

Therefore, the National Transportation Safety Board makes the following safety recommendations to the Research and Special Programs Administration:

> Evaluate, with the assistance of the Federal Railroad Administration, the Association of American Railroads, and the Railway Progress Institute, the deterioration of pressure relief devices through normal service and then develop inspection criteria to ensure that the pressure relief devices remain functional between regular inspection intervals. Incorporate these inspection criteria into the U.S. Department of Transportation *Hazardous Materials Regulations*. (R-01-03)

> Develop and implement policies and procedures to ensure that comprehensive reports concerning all significant failures of U.S. Department of Transportation specification tank cars, highway cargo tanks, and intermodal bulk containers containing hazardous materials are provided in writing to the Research and Special Programs Administration. (I-01-01)

In addition, the Safety Board reiterates Safety Recommendation I-00-06 to the Research and Special Programs Administration:

> <u>I-00-06</u>
>
> Within 1 year of the issuance of this safety recommendation, complete rulemaking on Docket HM-223, "Applicability of the *Hazardous Materials Regulations* to Loading, Unloading, and Storage," to establish, for all modes of transportation, safety requirements for loading and unloading hazardous materials.

The Safety Board also issued safety recommendations to the Federal Railroad Administration, the Association of American Railroads, the Railway Progress Institute, the Lyondell Chemical Company, the Olin Corporation, the Essroc Cement Corporation, and CP Recycling, Inc., and Affiliated Companies.

Please refer to Safety Recommendations R-01-03, I-01-01, and I-00-06 in your reply. If you need additional information, you may call (202) 314-6170.

Acting Chairman CARMODY and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

[Original Signed]

By: Carol J. Carmody
Acting Chairman

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: March 12, 2001

In reply refer to: I-01-02

Mr. Robert M. Rayner
President and Chief Operating Officer
Essroc Cement Corporation
3251 Bath Pike
Nazareth, Pennsylvania 18064

The National Transportation Safety Board is an independent Federal agency charged by Congress with investigating transportation accidents, determining their probable cause, and making recommendations to prevent similar accidents from occurring. We are providing the following information to urge your organization to take action on the safety recommendation in this letter. The Safety Board is vitally interested in this recommendation because it is designed to prevent accidents and save lives.

This recommendation addresses the sufficiency of safety requirements concerning the procedures used for loading and offloading railroad tank cars and other bulk containers used to transport hazardous materials. The recommendation is derived from the Safety Board's investigation of the catastrophic rupture of a railroad tank car containing hazardous waste near Clymers, Indiana, on February 18, 1999,[1] and is consistent with the evidence we found and the analysis we performed. As a result of this investigation, the Safety Board has issued 10 safety recommendations, 1 of which is addressed to the Essroc Cement Corporation. Information supporting this recommendation is discussed below. The Safety Board would appreciate a response from you within 90 days addressing the actions you have taken or intend to take to implement our recommendation.

About 12:05 a.m. on February 18, 1999, railroad tank car UTLX 643593, which was on the west unloading rack at the Essroc Cement Corporation cement plant near Clymers, Indiana, sustained a sudden and catastrophic rupture that propelled the tank car's tank about 750 feet and over multistory storage tanks. There were no injuries or fatalities. Total damages, including property damage and costs from lost production, were estimated at nearly $8.2 million. The National Transportation Safety Board determined that the probable cause of the accident was the failure of Essroc Cement Corporation (Essroc) and CP Recycling of Indiana (CPRIN) management to develop and implement safe procedures for offloading toluene diisocyanate (TDI) matter wastes,

[1] For more information, see forthcoming Hazardous Materials Accident Report NTSB/HZM-01/01: *Catastrophic Rupture of a Railroad Tank Car Containing Hazardous Waste Near Clymers, Indiana, February 18, 1999* (Washington, DC: National Transportation Safety Board, 2001).

resulting in the overpressurization of the tank car from chemical self-reaction and expansion of the TDI matter wastes.

Essroc had been attempting to transfer the substance in the tank car, TDI matter waste, to its kilns, where it was to be burned as a fuel. CPRIN was Essroc's on-site contractor for steam heating tank cars containing waste fuels. TDI matter waste is a flammable, toxic, and hazardous substance that must be disposed of in accordance with Environmental Protection Agency regulations. This tank car containing TDI matter waste had been sent to Essroc by the Arco Chemical Company (later purchased by the Lyondell Chemical Company [Lyondell]), which owned the Lake Charles, Louisiana, facility that had generated (in 1993) the TDI matter waste as a byproduct of TDI production.

The ownership of the Lake Charles facility changed three times between 1993, when the tank car was loaded, and 1999, when Essroc attempted to unload the tank. When UTLX 643593 was loaded in 1993, the Olin Corporation (Olin) owned and operated the Lake Charles plant. In December 1996, Olin sold its TDI production business, including the Lake Charles plant, to the Arco Chemical Company (Arco). In July 1998, Lyondell acquired Arco and its assets.

In 1996, Essroc began to accept TDI solvent blend wastes from Lake Charles as fuel for its cement production plant between Clymers and Logansport, Indiana. Blending agents such as HAN 906 solvent were added to the TDI solvent blend wastes at the Lake Charles plant before they were shipped to Essroc, to increase the fluidity of the wastes. However, beginning in spring 1998, nearly all the TDI wastes shipped to Essroc from Lake Charles were TDI matter wastes. Unlike the solvent blend wastes that had been "thinned" before shipment to Essroc, the TDI matter wastes were to be heated and offloaded from the tank car to a blending tank at the Essroc plant, where the wastes would be mixed with solvents to "thin" them before they were pumped to the kilns and burned. However, problems with the blending tank operation led Essroc to resort to offloading the TDI matter wastes from the tank cars and pumping them directly to the kilns, a procedure known as the "direct injection process." Essroc was using the direct injection process to offload the TDI matter wastes from UTLX 643593.

Whereas the waste profile for the solvent blend waste specified a maximum viscosity of 500 centipoise, the profile for the TDI matter waste indicated that its viscosity "varies." Because the TDI matter wastes in UTLX 643593 (and other tank cars sent to Essroc from Lake Charles) were to be blended at the Essroc plant, they typically were more viscous than the solvent blend wastes. Consequently, the TDI matter wastes probably had to be heated for longer periods and to higher temperatures than the solvent blend wastes, to make the TDI matter wastes sufficiently fluid for offloading from a tank car and pumping directly to the kilns.

The heating standard jointly employed by Essroc and CPRIN personnel was to heat the TDI matter waste until it was sufficiently fluid to flow. While CPRIN conducted the steam-heating operation, Essroc personnel drew samples from UTLX 643593 to measure the temperature of the wastes and to determine if the waste mixture was sufficiently fluid for offloading. Although Essroc and CPRIN personnel said they knew that the TDI matter wastes had to be heated to higher temperatures than the solvent blend wastes, Essroc and CPRIN claim they were unaware that Olin had recommended a maximum safe temperature range of 130 to 140º F for heating the TDI matter wastes. The Essroc facility supervisor said he was under the impression that the TDI matter wastes

could safely be heated to 200º F, whereas CPRIN stated that, although the TDI product should not be heated above 110º F because of possible quality control problems, these concerns did not apply to the TDI matter wastes.

Further, the offloading and steam-heating procedures used by Essroc and CPRIN did not include three critical heating and offloading practices that Olin had used at the Lake Charles plant: steam heating with low-pressure steam, nitrogen sparging while steam heating, and keeping the temperature of the waste mixture below 140º F. Through steam heating with low-pressure steam, the waste mixtures could be heated more slowly and could more easily be maintained at a temperature below the 130 to 140º F threshold recommended by Olin. Performing nitrogen sparging during the steam-heating process would cause the waste mixture at the bottom of the tank car to agitate, which would facilitate a more even distribution of heat throughout the entire waste mixture. The Safety Board concluded that, if Essroc and CPRIN had employed low-pressure steam to heat the wastes, used nitrogen sparging to facilitate even heating throughout the tank car, and maintained the temperature of the wastes below 140º F, the risk of localized overheating and expansion of the waste mixture would have been minimized, and the accident likely would not have occurred.

To determine why Essroc and CPRIN did not employ the procedures used at the Lake Charles plant, the Safety Board asked Olin, Lyondell, Essroc, and CPRIN to describe the information they exchanged about the heating of all TDI waste mixtures, the generation of gas from chemical self-reaction, the expansion of the wastes if overheated, nitrogen sparging, the establishment of temperature limits for the waste mixtures, and other special handling procedures.

Each company provided a different account regarding its responsibilities and the information it either provided or requested. All agreed that a Lake Charles TDI expert met with Essroc and CPRIN personnel at the Essroc plant in spring 1998 to provide instruction on handling and processing TDI matter wastes. The Lake Charles operators, Essroc, and CPRIN agreed that the TDI matter wastes could safely be heated to 125º F, compared to the 90 to 100º F range for the TDI solvent blend wastes. Essroc also acknowledged that the Lake Charles TDI expert had stated that a long, slow heating process was sometimes required to heat the TDI matter wastes. However, neither Essroc nor CPRIN acknowledged that the Lake Charles operators had set a maximum temperature limit or that the Lake Charles operators had recommended using nitrogen sparging and low-pressure steam-heating procedures. The Lake Charles operators, however, maintained that their TDI expert discussed nitrogen sparging, heating with low-pressure steam, and heating limits with Essroc and CPRIN personnel.

As can be seen from this diversity of opinion and recollection as to what was communicated between the producers and receivers in this instance regarding the appropriate procedures for offloading the TDI matter wastes, considerable confusion and misapprehension appears to have been prevalent among those parties that handled the TDI waste mixtures. Given the potentially hazardous nature of TDI matter wastes, such ambiguity is unacceptable.

The investigation also revealed other areas of imprecision. For instance, responsibility for offloading at the Essroc plant seems to have been unclear. Essroc stated that CPRIN was responsible for steam heating the TDI product so that it was sufficiently fluid that it could be pumped to the cement kilns. CPRIN, however, stated that Essroc retained operational authority over the heating and offloading process.

Further, no one at the Essroc plant had comprehensive, written instructions on the offloading procedures to be used. Although Essroc had written procedures for offloading the TDI matter wastes to a fixed blending tank, these procedures did not include details about heating practices, nitrogen sparging, or maximum temperature limits. Then, when Essroc adopted the direct injection procedure in place of blending in a fixed tank, even less information was available. Neither Essroc nor CPRIN had any written procedures for heating and offloading the TDI matter wastes for direct injection of these wastes to the kilns.

Therefore, based on the discrepancies between Essroc's and CPRIN's accounts of their respective roles and responsibilities for handling and disposing of TDI matter wastes and the absence of specific, written procedures for heating and offloading these wastes by direct injection, the Safety Board concluded that Essroc and CPRIN failed to develop and implement appropriate heating and offloading procedures for the TDI matter wastes at the Logansport plant, which resulted in the use of unsafe offloading practices at the plant.

With respect to the Lake Charles operation's procedures, Olin stated, in its response to Safety Board inquiries about whether it had written procedures for heating and offloading TDI wastes, that any written procedures that might have existed had been turned over to Arco (later Lyondell). Lyondell stated that Arco/Lyondell did not have specific, written procedures for on-site blending of the TDI waste mixtures and offloading them from tank cars. Arco/Lyondell had written procedures for blending solvent blend wastes in a fixed tank and then transferring them from the fixed tank into tank cars. These procedures set the temperature and viscosity limits for the solvent blend wastes in the fixed blending tank. However, neither Olin nor Arco/Lyondell had written operating procedures or limitations that addressed the potential for gas generation or product expansion, the maximum temperature and time for heating the TDI wastes, or the maximum product viscosity for offloading tank cars. Therefore, no one at Lake Charles appears to have had comprehensive, written procedures for handling the TDI wastes.

The Safety Board also considers that the implementation of comprehensive, written procedures for loading and offloading chemicals or waste materials exhibiting properties that require special handling must incorporate methods that will detect internal tank conditions and accurately reflect the thermophysical state of all of the material in the tank vessel. The written procedures should specify values or ranges for important material properties such as melting temperature, flash point, maximum allowable product temperature, and viscosity. Further, offloading procedures developed and validated under certain environmental conditions may lead to or cause catastrophic failures or other potential problems in offloading the material when the environmental conditions vary from the baseline conditions.

Partially because there is no written record to which it may refer, the Safety Board cannot decisively determine what information and guidance were provided by the Lake Charles operators to Essroc and CPRIN on heating and offloading TDI matter from tank cars or what consideration, if any, was given to detection of internal tank car conditions that were potentially catastrophic. Nor can the Safety Board be sure what guidance may have been provided by the Lake Charles operators but not implemented by Essroc and CPRIN. Nevertheless, given the differences between the accounts offered by these companies about the guidance given or requested and the lack of comprehensive, written procedures at Lake Charles for handling TDI

wastes, the Safety Board concluded that Olin and Arco (now Lyondell) did not provide Essroc with comprehensive, written information about safe handling procedures for TDI matter wastes.

The Safety Board considers that the producer/shipper and the consignee/end-user of any chemical or waste material have joint responsibility for determining and implementing comprehensive, written procedures for the transfer of any chemical or waste material to and from a tank car, highway cargo tank, or other bulk container when the chemical or waste material exhibits properties that require special handling. Such properties would include those identified with the TDI matter wastes involved in this accident, such as temperature and heating effects, means of self-reaction, and the byproducts of reaction, including the generation of gases and product expansion.

In the Safety Board's view, both parties to the transport of a hazardous material have information vital to its safe transfer. The producer/shipper has detailed knowledge about the properties of the chemical or waste material, while the consignee/end-user has specific information about the transfer facilities at the destination. Ideally, the result of the collaboration between the producer/shipper and consignee/end-user should be the development and implementation of specific, written transfer procedures that address each unique property of the chemical or waste material in the context of the physical layout of a given plant or facility.

The importance and effectiveness of such cooperation is evidenced by what happened when the TDI waste materials had to be moved after the Clymers accident took place. Following the accident at the Essroc plant, Olin and the waste disposal companies that were contracted to unload the remaining tank cars at a transfer facility in Deer Park, Texas, jointly developed comprehensive, written procedures that established viscosity and temperature limits and called for nitrogen sparging. Consequently, the transfer and offloading took place without incident.

Therefore, the National Transportation Safety Board makes the following safety recommendation to the Essroc Cement Corporation:

> Collaborate with applicable producers, shippers, consignees, and end-users in the development and implementation of specific and written procedures for the loading or offloading of any chemical or waste material from a railroad tank car, highway cargo tank, or other bulk transportation vessel when the chemical or waste material exhibits properties that require special handling or processing during the loading or offloading operation. (I-01-02)

The Safety Board also issued safety recommendations to the Federal Railroad Administration, the Research and Special Programs Administration, the Railway Progress Institute, the Association of American Railroads, the Lyondell Chemical Company, the Olin Corporation, and CP Recycling, Inc., and Affiliated Companies. In your response to the recommendation in this letter, please refer to Safety Recommendation I-01-02. If you need additional information, you may call (202) 314-6170.

Acting Chairman CARMODY and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in this recommendation.

[Original Signed]

By: Carol J. Carmody
Acting Chairman

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: March 12, 2001

In reply refer to: I-01-03

Mr. Paul D. Knowlson
President and Chief Executive Officer
CP Recycling, Inc., and Affiliated Companies
3375 Merriam Avenue
Suite 102
Muskegon, Michigan 49444

The National Transportation Safety Board is an independent Federal agency charged by Congress with investigating transportation accidents, determining their probable cause, and making recommendations to prevent similar accidents from occurring. We are providing the following information to urge your organization to take action on the safety recommendation in this letter. The Safety Board is vitally interested in this recommendation because it is designed to prevent accidents and save lives.

This recommendation addresses the sufficiency of safety requirements concerning the procedures used for loading and offloading railroad tank cars and other bulk containers used to transport hazardous materials. The recommendation is derived from the Safety Board's investigation of the catastrophic rupture of a railroad tank car containing hazardous waste near Clymers, Indiana, on February 18, 1999,[1] and is consistent with the evidence we found and the analysis we performed. As a result of this investigation, the Safety Board has issued 10 safety recommendations, 1 of which is addressed to CP Recycling, Inc., and Affiliated Companies. Information supporting this recommendation is discussed below. The Safety Board would appreciate a response from you within 90 days addressing the actions you have taken or intend to take to implement our recommendation.

About 12:05 a.m. on February 18, 1999, railroad tank car UTLX 643593, which was on the west unloading rack at the Essroc Cement Corporation cement plant near Clymers, Indiana, sustained a sudden and catastrophic rupture that propelled the tank car's tank about 750 feet and over multistory storage tanks. There were no injuries or fatalities. Total damages, including property damage and costs from lost production, were estimated at nearly $8.2 million. The National Transportation Safety Board determined that the probable cause of the accident was the failure of Essroc Cement Corporation (Essroc) and CP Recycling of Indiana (CPRIN) management to develop and implement safe procedures for offloading toluene diisocyanate (TDI) matter wastes,

[1] For more information, see forthcoming Hazardous Materials Accident Report NTSB/HZM-01/01: *Catastrophic Rupture of a Railroad Tank Car Containing Hazardous Waste Near Clymers, Indiana, February 18, 1999* (Washington, DC: National Transportation Safety Board, 2001).

resulting in the overpressurization of the tank car from chemical self-reaction and expansion of the TDI matter wastes.

Essroc had been attempting to transfer the substance in the tank car, TDI matter waste, to its kilns, where it was to be burned as a fuel. CPRIN[2] was Essroc's on-site contractor for steam heating tank cars containing waste fuels. TDI matter waste is a flammable, toxic, and hazardous substance that must be disposed of in accordance with Environmental Protection Agency regulations. This tank car containing TDI matter waste had been sent to Essroc by the Arco Chemical Company (later purchased by the Lyondell Chemical Company [Lyondell]), which owned the Lake Charles, Louisiana, facility that had generated (in 1993) the TDI matter waste as a byproduct of TDI production.

The ownership of the Lake Charles facility changed three times between 1993, when the tank car was loaded, and 1999, when Essroc attempted to unload the tank. When UTLX 643593 was loaded in 1993, the Olin Corporation (Olin) owned and operated the Lake Charles plant. In December 1996, Olin sold its TDI production business, including the Lake Charles plant, to the Arco Chemical Company (Arco). In July 1998, Lyondell acquired Arco and its assets.

In 1996, Essroc began to accept TDI solvent blend wastes from Lake Charles as fuel for its cement production plant between Clymers and Logansport, Indiana. Blending agents such as HAN 906 solvent were added to the TDI solvent blend wastes at the Lake Charles plant before they were shipped to Essroc, to increase the fluidity of the wastes. However, beginning in spring 1998, nearly all the TDI wastes shipped to Essroc from Lake Charles were TDI matter wastes. Unlike the solvent blend wastes that had been "thinned" before shipment to Essroc, the TDI matter wastes were to be heated and offloaded from the tank car to a blending tank at the Essroc plant, where the wastes would be mixed with solvents to "thin" them before they were pumped to the kilns and burned. However, problems with the blending tank operation led Essroc to resort to offloading the TDI matter wastes from the tank cars and pumping them directly to the kilns, a procedure known as the "direct injection process." Essroc was using the direct injection process to offload the TDI matter wastes from UTLX 643593.

Whereas the waste profile for the solvent blend waste specified a maximum viscosity of 500 centipoise, the profile for the TDI matter waste indicated that its viscosity "varies." Because the TDI matter wastes in UTLX 643593 (and other tank cars sent to Essroc from Lake Charles) were to be blended at the Essroc plant, they typically were more viscous than the solvent blend wastes. Consequently, the TDI matter wastes probably had to be heated for longer periods and to higher temperatures than the solvent blend wastes, to make the TDI matter wastes sufficiently fluid for offloading from a tank car and pumping directly to the kilns.

The heating standard jointly employed by Essroc and CPRIN personnel was to heat the TDI matter waste until it was sufficiently fluid to flow. While CPRIN conducted the steam-heating operation, Essroc personnel drew samples from UTLX 643593 to measure the temperature of the wastes and to determine if the waste mixture was sufficiently fluid for offloading. Although Essroc and CPRIN personnel said they knew that the TDI matter wastes had to be heated to higher temperatures than the solvent blend wastes, Essroc and CPRIN claim they were unaware that Olin

[2] CPRIN is a subsidiary of your organization.

had recommended a maximum safe temperature range of 130 to 140º F for heating the TDI matter wastes. The Essroc facility supervisor said he was under the impression that the TDI matter wastes could safely be heated to 200º F, whereas CPRIN stated that, although the TDI product should not be heated above 110º F because of possible quality control problems, these concerns did not apply to the TDI matter wastes.

Further, the offloading and steam-heating procedures used by Essroc and CPRIN did not include three critical heating and offloading practices that Olin had used at the Lake Charles plant: steam heating with low-pressure steam, nitrogen sparging while steam heating, and keeping the temperature of the waste mixture below 140º F. Through steam heating with low-pressure steam, the waste mixtures could be heated more slowly and could more easily be maintained at a temperature below the 130 to 140º F threshold recommended by Olin. Performing nitrogen sparging during the steam-heating process would cause the waste mixture at the bottom of the tank car to agitate, which would facilitate a more even distribution of heat throughout the entire waste mixture. The Safety Board concluded that, if Essroc and CPRIN had employed low-pressure steam to heat the wastes, used nitrogen sparging to facilitate even heating throughout the tank car, and maintained the temperature of the wastes below 140º F, the risk of localized overheating and expansion of the waste mixture would have been minimized, and the accident likely would not have occurred.

To determine why Essroc and CPRIN did not employ the procedures used at the Lake Charles plant, the Safety Board asked Olin, Lyondell, Essroc, and CPRIN to describe the information they exchanged about the heating of all TDI waste mixtures, the generation of gas from chemical self-reaction, the expansion of the wastes if overheated, nitrogen sparging, the establishment of temperature limits for the waste mixtures, and other special handling procedures.

Each company provided a different account regarding its responsibilities and the information it either provided or requested. All agreed that a Lake Charles TDI expert met with Essroc and CPRIN personnel at the Essroc plant in spring 1998 to provide instruction on handling and processing TDI matter wastes. The Lake Charles operators, Essroc, and CPRIN agreed that the TDI matter wastes could safely be heated to 125º F, compared to the 90 to 100º F range for the TDI solvent blend wastes. Essroc also acknowledged that the Lake Charles TDI expert had stated that a long, slow heating process was sometimes required to heat the TDI matter wastes. However, neither Essroc nor CPRIN acknowledged that the Lake Charles operators had set a maximum temperature limit or that the Lake Charles operators had recommended using nitrogen sparging and low-pressure steam-heating procedures. The Lake Charles operators, however, maintained that their TDI expert discussed nitrogen sparging, heating with low-pressure steam, and heating limits with Essroc and CPRIN personnel.

As can be seen from this diversity of opinion and recollection as to what was communicated between the producers and receivers in this instance regarding the appropriate procedures for offloading the TDI matter wastes, considerable confusion and misapprehension appears to have been prevalent among those parties that handled the TDI waste mixtures. Given the potentially hazardous nature of TDI matter wastes, such ambiguity is unacceptable.

The investigation also revealed other areas of imprecision. For instance, responsibility for offloading at the Essroc plant seems to have been unclear. Essroc stated that CPRIN was responsible for steam heating the TDI product so that it was sufficiently fluid that it could be pumped to the cement kilns. CPRIN, however, stated that Essroc retained operational authority over the heating and offloading process.

Further, no one at the Essroc plant had comprehensive, written instructions on the offloading procedures to be used. Although Essroc had written procedures for offloading the TDI matter wastes to a fixed blending tank, these procedures did not include details about heating practices, nitrogen sparging, or maximum temperature limits. Then, when Essroc adopted the direct injection procedure in place of blending in a fixed tank, even less information was available. Neither Essroc nor CPRIN had any written procedures for heating and offloading the TDI matter wastes for direct injection of these wastes to the kilns.

Therefore, based on the discrepancies between Essroc's and CPRIN's accounts of their respective roles and responsibilities for handling and disposing of TDI matter wastes and the absence of specific, written procedures for heating and offloading these wastes by direct injection, the Safety Board concluded that Essroc and CPRIN failed to develop and implement appropriate heating and offloading procedures for the TDI matter wastes at the Logansport plant, which resulted in the use of unsafe offloading practices at the plant.

With respect to the Lake Charles operation's procedures, Olin stated, in its response to Safety Board inquiries about whether it had written procedures for heating and offloading TDI wastes, that any written procedures that might have existed had been turned over to Arco (later Lyondell). Lyondell stated that Arco/Lyondell did not have specific, written procedures for on-site blending of the TDI waste mixtures and offloading them from tank cars. Arco/Lyondell had written procedures for blending solvent blend wastes in a fixed tank and then transferring them from the fixed tank into tank cars. These procedures set the temperature and viscosity limits for the solvent blend wastes in the fixed blending tank. However, neither Olin nor Arco/Lyondell had written operating procedures or limitations that addressed the potential for gas generation or product expansion, the maximum temperature and time for heating the TDI wastes, or the maximum product viscosity for offloading tank cars. Therefore, no one at Lake Charles appears to have had comprehensive, written procedures for handling the TDI wastes.

The Safety Board also considers that the implementation of comprehensive, written procedures for loading and offloading chemicals or waste materials exhibiting properties that require special handling must incorporate methods that will detect internal tank conditions and accurately reflect the thermophysical state of all of the material in the tank vessel. The written procedures should specify values or ranges for important material properties such as melting temperature, flash point, maximum allowable product temperature, and viscosity. Further, offloading procedures developed and validated under certain environmental conditions may lead to or cause catastrophic failures or other potential problems in offloading the material when the environmental conditions vary from the baseline conditions.

Partially because there is no written record to which it may refer, the Safety Board cannot decisively determine what information and guidance were provided by the Lake Charles operators to Essroc and CPRIN on heating and offloading TDI matter from tank cars or what consideration, if any, was given to detection of internal tank car conditions that were potentially catastrophic. Nor can the Safety Board be sure what guidance may have been provided by the Lake Charles operators but not implemented by Essroc and CPRIN. Nevertheless, given the differences between the accounts offered by these companies about the guidance given or requested and the lack of comprehensive, written procedures at Lake Charles for handling TDI wastes, the Safety Board concluded that Olin and Arco (now Lyondell) did not provide Essroc with comprehensive, written information about safe handling procedures for TDI matter wastes.

The Safety Board considers that the producer/shipper and the consignee/end-user of any chemical or waste material have joint responsibility for determining and implementing comprehensive, written procedures for the transfer of any chemical or waste material to and from a tank car, highway cargo tank, or other bulk container when the chemical or waste material exhibits properties that require special handling. Such properties would include those identified with the TDI matter wastes involved in this accident, such as temperature and heating effects, means of self-reaction, and the byproducts of reaction, including the generation of gases and product expansion.

In the Safety Board's view, both parties to the transport of a hazardous material have information vital to its safe transfer. The producer/shipper has detailed knowledge about the properties of the chemical or waste material, while the consignee/end-user has specific information about the transfer facilities at the destination. Ideally, the result of the collaboration between the producer/shipper and consignee/end-user should be the development and implementation of specific, written transfer procedures that address each unique property of the chemical or waste material in the context of the physical layout of a given plant or facility.

The importance and effectiveness of such cooperation is evidenced by what happened when the TDI waste materials had to be moved after the Clymers accident took place. Following the accident at the Essroc plant, Olin and the waste disposal companies that were contracted to unload the remaining tank cars at a transfer facility in Deer Park, Texas, jointly developed comprehensive, written procedures that established viscosity and temperature limits and called for nitrogen sparging. Consequently, the transfer and offloading took place without incident.

Therefore, the National Transportation Safety Board makes the following safety recommendation to CP Recycling, Inc., and Affiliated Companies:

> Collaborate with applicable producers, shippers, consignees, and end-users in the development and implementation of specific and written procedures for the loading or offloading of any chemical or waste material from a railroad tank car, highway cargo tank, or other bulk transportation vessel when the chemical or waste material exhibits properties that require special handling or processing during the loading or offloading operation. (I-01-03)

The Safety Board also issued safety recommendations to the Federal Railroad Administration, the Research and Special Programs Administration, the Railway Progress Institute, the Association of American Railroads, the Essroc Cement Corporation, the Lyondell Chemical Company, and the Olin Corporation. In your response to the recommendation in this letter, please refer to Safety Recommendation I-01-03. If you need additional information, you may call (202) 314-6170.

Acting Chairman CARMODY and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in this recommendation.

[Original Signed]

By: Carol J. Carmody
Acting Chairman

National Transportation Safety Board
Washington, D.C. 20594

Safety Recommendation

Date: March 12, 2001

In reply refer to: I-01-04

Mr. Donald W. Griffin
Chairman
Olin Corporation
501 Merritt Seven
Norwalk, Connecticut 06856-4500

The National Transportation Safety Board is an independent Federal agency charged by Congress with investigating transportation accidents, determining their probable cause, and making recommendations to prevent similar accidents from occurring. We are providing the following information to urge your organization to take action on the safety recommendation in this letter. The Safety Board is vitally interested in this recommendation because it is designed to prevent accidents and save lives.

This recommendation addresses the sufficiency of safety requirements concerning the procedures used for loading and offloading railroad tank cars and other bulk containers used to transport hazardous materials. The recommendation is derived from the Safety Board's investigation of the catastrophic rupture of a railroad tank car containing hazardous waste near Clymers, Indiana, on February 18, 1999,[1] and is consistent with the evidence we found and the analysis we performed. As a result of this investigation, the Safety Board has issued 10 safety recommendations, 1 of which is addressed to the Olin Corporation. Information supporting this recommendation is discussed below. The Safety Board would appreciate a response from you within 90 days addressing the actions you have taken or intend to take to implement our recommendation.

About 12:05 a.m. on February 18, 1999, railroad tank car UTLX 643593, which was on the west unloading rack at the Essroc Cement Corporation cement plant near Clymers, Indiana, sustained a sudden and catastrophic rupture that propelled the tank car's tank about 750 feet and over multistory storage tanks. There were no injuries or fatalities. Total damages, including property damage and costs from lost production, were estimated at nearly $8.2 million. The National Transportation Safety Board determined that the probable cause of the accident was the failure of Essroc Cement Corporation (Essroc) and CP Recycling of Indiana (CPRIN) management to develop and implement safe procedures for offloading toluene diisocyanate (TDI) matter wastes,

[1] For more information, see forthcoming Hazardous Materials Accident Report NTSB/HZM-01/01: *Catastrophic Rupture of a Railroad Tank Car Containing Hazardous Waste Near Clymers, Indiana, February 18, 1999* (Washington, DC: National Transportation Safety Board, 2001).

resulting in the overpressurization of the tank car from chemical self-reaction and expansion of the TDI matter wastes.

Essroc had been attempting to transfer the substance in the tank car, TDI matter waste, to its kilns, where it was to be burned as a fuel. CPRIN was Essroc's on-site contractor for steam heating tank cars containing waste fuels. TDI matter waste is a flammable, toxic, and hazardous substance that must be disposed of in accordance with Environmental Protection Agency regulations. This tank car containing TDI matter waste had been sent to Essroc by the Arco Chemical Company (later purchased by the Lyondell Chemical Company [Lyondell]), which owned the Lake Charles, Louisiana, facility that had generated (in 1993) the TDI matter waste as a byproduct of TDI production.

The ownership of the Lake Charles facility changed three times between 1993, when the tank car was loaded, and 1999, when Essroc attempted to unload the tank. When UTLX 643593 was loaded in 1993, the Olin Corporation (Olin) owned and operated the Lake Charles plant. In December 1996, Olin sold its TDI production business, including the Lake Charles plant, to the Arco Chemical Company (Arco). In July 1998, Lyondell acquired Arco and its assets.

In 1996, Essroc began to accept TDI solvent blend wastes from Lake Charles as fuel for its cement production plant between Clymers and Logansport, Indiana. Blending agents such as HAN 906 solvent were added to the TDI solvent blend wastes at the Lake Charles plant before they were shipped to Essroc, to increase the fluidity of the wastes. However, beginning in spring 1998, nearly all the TDI wastes shipped to Essroc from Lake Charles were TDI matter wastes. Unlike the solvent blend wastes that had been "thinned" before shipment to Essroc, the TDI matter wastes were to be heated and offloaded from the tank car to a blending tank at the Essroc plant, where the wastes would be mixed with solvents to "thin" them before they were pumped to the kilns and burned. However, problems with the blending tank operation led Essroc to resort to offloading the TDI matter wastes from the tank cars and pumping them directly to the kilns, a procedure known as the "direct injection process." Essroc was using the direct injection process to offload the TDI matter wastes from UTLX 643593.

Whereas the waste profile for the solvent blend waste specified a maximum viscosity of 500 centipoise, the profile for the TDI matter waste indicated that its viscosity "varies." Because the TDI matter wastes in UTLX 643593 (and other tank cars sent to Essroc from Lake Charles) were to be blended at the Essroc plant, they typically were more viscous than the solvent blend wastes. Consequently, the TDI matter wastes probably had to be heated for longer periods and to higher temperatures than the solvent blend wastes, to make the TDI matter wastes sufficiently fluid for offloading from a tank car and pumping directly to the kilns.

The heating standard jointly employed by Essroc and CPRIN personnel was to heat the TDI matter waste until it was sufficiently fluid to flow. While CPRIN conducted the steam-heating operation, Essroc personnel drew samples from UTLX 643593 to measure the temperature of the wastes and to determine if the waste mixture was sufficiently fluid for offloading. Although Essroc and CPRIN personnel said they knew that the TDI matter wastes had to be heated to higher temperatures than the solvent blend wastes, Essroc and CPRIN claim they were unaware that Olin had recommended a maximum safe temperature range of 130 to 140º F for heating the TDI matter wastes. The Essroc facility supervisor said he was under the impression that the TDI matter wastes

could safely be heated to 200º F, whereas CPRIN stated that, although the TDI product should not be heated above 110º F because of possible quality control problems, these concerns did not apply to the TDI matter wastes.

Further, the offloading and steam-heating procedures used by Essroc and CPRIN did not include three critical heating and offloading practices that Olin had used at the Lake Charles plant: steam heating with low-pressure steam, nitrogen sparging while steam heating, and keeping the temperature of the waste mixture below 140º F. Through steam heating with low-pressure steam, the waste mixtures could be heated more slowly and could more easily be maintained at a temperature below the 130 to 140º F threshold recommended by Olin. Performing nitrogen sparging during the steam-heating process would cause the waste mixture at the bottom of the tank car to agitate, which would facilitate a more even distribution of heat throughout the entire waste mixture. The Safety Board concluded that, if Essroc and CPRIN had employed low-pressure steam to heat the wastes, used nitrogen sparging to facilitate even heating throughout the tank car, and maintained the temperature of the wastes below 140º F, the risk of localized overheating and expansion of the waste mixture would have been minimized, and the accident likely would not have occurred.

To determine why Essroc and CPRIN did not employ the procedures used at the Lake Charles plant, the Safety Board asked Olin, Lyondell, Essroc, and CPRIN to describe the information they exchanged about the heating of all TDI waste mixtures, the generation of gas from chemical self-reaction, the expansion of the wastes if overheated, nitrogen sparging, the establishment of temperature limits for the waste mixtures, and other special handling procedures.

Each company provided a different account regarding its responsibilities and the information it either provided or requested. All agreed that a Lake Charles TDI expert met with Essroc and CPRIN personnel at the Essroc plant in spring 1998 to provide instruction on handling and processing TDI matter wastes. The Lake Charles operators, Essroc, and CPRIN agreed that the TDI matter wastes could safely be heated to 125º F, compared to the 90 to 100º F range for the TDI solvent blend wastes. Essroc also acknowledged that the Lake Charles TDI expert had stated that a long, slow heating process was sometimes required to heat the TDI matter wastes. However, neither Essroc nor CPRIN acknowledged that the Lake Charles operators had set a maximum temperature limit or that the Lake Charles operators had recommended using nitrogen sparging and low-pressure steam-heating procedures. The Lake Charles operators, however, maintained that their TDI expert discussed nitrogen sparging, heating with low-pressure steam, and heating limits with Essroc and CPRIN personnel.

As can be seen from this diversity of opinion and recollection as to what was communicated between the producers and receivers in this instance regarding the appropriate procedures for offloading the TDI matter wastes, considerable confusion and misapprehension appears to have been prevalent among those parties that handled the TDI waste mixtures. Given the potentially hazardous nature of TDI matter wastes, such ambiguity is unacceptable.

The investigation also revealed other areas of imprecision. For instance, responsibility for offloading at the Essroc plant seems to have been unclear. Essroc stated that CPRIN was responsible for steam heating the TDI product so that it was sufficiently fluid that it could be pumped to the cement kilns. CPRIN, however, stated that Essroc retained operational authority over the heating and offloading process.

Further, no one at the Essroc plant had comprehensive, written instructions on the offloading procedures to be used. Although Essroc had written procedures for offloading the TDI matter wastes to a fixed blending tank, these procedures did not include details about heating practices, nitrogen sparging, or maximum temperature limits. Then, when Essroc adopted the direct injection procedure in place of blending in a fixed tank, even less information was available. Neither Essroc nor CPRIN had any written procedures for heating and offloading the TDI matter wastes for direct injection of these wastes to the kilns.

Therefore, based on the discrepancies between Essroc's and CPRIN's accounts of their respective roles and responsibilities for handling and disposing of TDI matter wastes and the absence of specific, written procedures for heating and offloading these wastes by direct injection, the Safety Board concluded that Essroc and CPRIN failed to develop and implement appropriate heating and offloading procedures for the TDI matter wastes at the Logansport plant, which resulted in the use of unsafe offloading practices at the plant.

With respect to the Lake Charles operation's procedures, Olin stated, in its response to Safety Board inquiries about whether it had written procedures for heating and offloading TDI wastes, that any written procedures that might have existed had been turned over to Arco (later Lyondell). Lyondell stated that Arco/Lyondell did not have specific, written procedures for on-site blending of the TDI waste mixtures and offloading them from tank cars. Arco/Lyondell had written procedures for blending solvent blend wastes in a fixed tank and then transferring them from the fixed tank into tank cars. These procedures set the temperature and viscosity limits for the solvent blend wastes in the fixed blending tank. However, neither Olin nor Arco/Lyondell had written operating procedures or limitations that addressed the potential for gas generation or product expansion, the maximum temperature and time for heating the TDI wastes, or the maximum product viscosity for offloading tank cars. Therefore, no one at Lake Charles appears to have had comprehensive, written procedures for handling the TDI wastes.

The Safety Board also considers that the implementation of comprehensive, written procedures for loading and offloading chemicals or waste materials exhibiting properties that require special handling must incorporate methods that will detect internal tank conditions and accurately reflect the thermophysical state of all of the material in the tank vessel. The written procedures should specify values or ranges for important material properties such as melting temperature, flash point, maximum allowable product temperature, and viscosity. Further, offloading procedures developed and validated under certain environmental conditions may lead to or cause catastrophic failures or other potential problems in offloading the material when the environmental conditions vary from the baseline conditions.

Partially because there is no written record to which it may refer, the Safety Board cannot decisively determine what information and guidance were provided by the Lake Charles operators to Essroc and CPRIN on heating and offloading TDI matter from tank cars or what consideration, if any, was given to detection of internal tank car conditions that were potentially catastrophic. Nor can the Safety Board be sure what guidance may have been provided by the Lake Charles operators but not implemented by Essroc and CPRIN. Nevertheless, given the differences between the accounts offered by these companies about the guidance given or requested and the lack of comprehensive, written procedures at Lake Charles for handling TDI

wastes, the Safety Board concluded that Olin and Arco (now Lyondell) did not provide Essroc with comprehensive, written information about safe handling procedures for TDI matter wastes.

The Safety Board considers that the producer/shipper and the consignee/end-user of any chemical or waste material have joint responsibility for determining and implementing comprehensive, written procedures for the transfer of any chemical or waste material to and from a tank car, highway cargo tank, or other bulk container when the chemical or waste material exhibits properties that require special handling. Such properties would include those identified with the TDI matter wastes involved in this accident, such as temperature and heating effects, means of self-reaction, and the byproducts of reaction, including the generation of gases and product expansion.

In the Safety Board's view, both parties to the transport of a hazardous material have information vital to its safe transfer. The producer/shipper has detailed knowledge about the properties of the chemical or waste material, while the consignee/end-user has specific information about the transfer facilities at the destination. Ideally, the result of the collaboration between the producer/shipper and consignee/end-user should be the development and implementation of specific, written transfer procedures that address each unique property of the chemical or waste material in the context of the physical layout of a given plant or facility.

The importance and effectiveness of such cooperation is evidenced by what happened when the TDI waste materials had to be moved after the Clymers accident took place. Following the accident at the Essroc plant, Olin and the waste disposal companies that were contracted to unload the remaining tank cars at a transfer facility in Deer Park, Texas, jointly developed comprehensive, written procedures that established viscosity and temperature limits and called for nitrogen sparging. Consequently, the transfer and offloading took place without incident.

Therefore, the National Transportation Safety Board makes the following safety recommendation to the Olin Corporation:

> Collaborate with applicable producers, shippers, consignees, and end-users in the development and implementation of specific and written procedures for the loading or offloading of any chemical or waste material from a railroad tank car, highway cargo tank, or other bulk transportation vessel when the chemical or waste material exhibits properties that require special handling or processing during the loading or offloading operation. (I-01-04)

The Safety Board also issued safety recommendations to the Federal Railroad Administration, the Research and Special Programs Administration, the Railway Progress Institute, the Association of American Railroads, the Essroc Cement Corporation, the Lyondell Chemical Company, and CP Recycling, Inc., and Affiliated Companies. In your response to the recommendation in this letter, please refer to Safety Recommendation I-01-04. If you need additional information, you may call (202) 314-6170.

Acting Chairman CARMODY and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in this recommendation.

[Original Signed]

By: Carol J. Carmody
Acting Chairman

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: March 12, 2001

In reply to refer to: I-01-05

Mr. Dan F. Smith
President and Chief Executive Officer
Lyondell Chemical Company
Post Office Box 3646
Houston, Texas 77253-3646

The National Transportation Safety Board is an independent Federal agency charged by Congress with investigating transportation accidents, determining their probable cause, and making recommendations to prevent similar accidents from occurring. We are providing the following information to urge your organization to take action on the safety recommendation in this letter. The Safety Board is vitally interested in this recommendation because it is designed to prevent accidents and save lives.

This recommendation addresses the sufficiency of safety requirements concerning the procedures used for loading and offloading railroad tank cars and other bulk containers used to transport hazardous materials. The recommendation is derived from the Safety Board's investigation of the catastrophic rupture of a railroad tank car containing hazardous waste near Clymers, Indiana, on February 18, 1999,[1] and is consistent with the evidence we found and the analysis we performed. As a result of this investigation, the Safety Board has issued 10 safety recommendations, 1 of which is addressed to the Lyondell Chemical Company. Information supporting this recommendation is discussed below. The Safety Board would appreciate a response from you within 90 days addressing the actions you have taken or intend to take to implement our recommendation.

About 12:05 a.m. on February 18, 1999, railroad tank car UTLX 643593, which was on the west unloading rack at the Essroc Cement Corporation cement plant near Clymers, Indiana, sustained a sudden and catastrophic rupture that propelled the tank car's tank about 750 feet and over multistory storage tanks. There were no injuries or fatalities. Total damages, including property damage and costs from lost production, were estimated at nearly $8.2 million. The National Transportation Safety Board determined that the probable cause of the accident was the failure of Essroc Cement Corporation (Essroc) and CP Recycling of Indiana (CPRIN) management to develop and implement safe procedures for offloading toluene diisocyanate (TDI) matter wastes,

[1] For more information, see forthcoming Hazardous Materials Accident Report NTSB/HZM-01/01: *Catastrophic Rupture of a Railroad Tank Car Containing Hazardous Waste Near Clymers, Indiana, February 18, 1999* (Washington, DC: National Transportation Safety Board, 2001).

resulting in the overpressurization of the tank car from chemical self-reaction and expansion of the TDI matter wastes.

Essroc had been attempting to transfer the substance in the tank car, TDI matter waste, to its kilns, where it was to be burned as a fuel. CPRIN was Essroc's on-site contractor for steam heating tank cars containing waste fuels. TDI matter waste is a flammable, toxic, and hazardous substance that must be disposed of in accordance with Environmental Protection Agency regulations. This tank car containing TDI matter waste had been sent to Essroc by the Arco Chemical Company (later purchased by the Lyondell Chemical Company [Lyondell]), which owned the Lake Charles, Louisiana, facility that had generated (in 1993) the TDI matter waste as a byproduct of TDI production.

The ownership of the Lake Charles facility changed three times between 1993, when the tank car was loaded, and 1999, when Essroc attempted to unload the tank. When UTLX 643593 was loaded in 1993, the Olin Corporation (Olin) owned and operated the Lake Charles plant. In December 1996, Olin sold its TDI production business, including the Lake Charles plant, to the Arco Chemical Company (Arco). In July 1998, Lyondell acquired Arco and its assets.

In 1996, Essroc began to accept TDI solvent blend wastes from Lake Charles as fuel for its cement production plant between Clymers and Logansport, Indiana. Blending agents such as HAN 906 solvent were added to the TDI solvent blend wastes at the Lake Charles plant before they were shipped to Essroc, to increase the fluidity of the wastes. However, beginning in spring 1998, nearly all the TDI wastes shipped to Essroc from Lake Charles were TDI matter wastes. Unlike the solvent blend wastes that had been "thinned" before shipment to Essroc, the TDI matter wastes were to be heated and offloaded from the tank car to a blending tank at the Essroc plant, where the wastes would be mixed with solvents to "thin" them before they were pumped to the kilns and burned. However, problems with the blending tank operation led Essroc to resort to offloading the TDI matter wastes from the tank cars and pumping them directly to the kilns, a procedure known as the "direct injection process." Essroc was using the direct injection process to offload the TDI matter wastes from UTLX 643593.

Whereas the waste profile for the solvent blend waste specified a maximum viscosity of 500 centipoise, the profile for the TDI matter waste indicated that its viscosity "varies." Because the TDI matter wastes in UTLX 643593 (and other tank cars sent to Essroc from Lake Charles) were to be blended at the Essroc plant, they typically were more viscous than the solvent blend wastes. Consequently, the TDI matter wastes probably had to be heated for longer periods and to higher temperatures than the solvent blend wastes, to make the TDI matter wastes sufficiently fluid for offloading from a tank car and pumping directly to the kilns.

The heating standard jointly employed by Essroc and CPRIN personnel was to heat the TDI matter waste until it was sufficiently fluid to flow. While CPRIN conducted the steam-heating operation, Essroc personnel drew samples from UTLX 643593 to measure the temperature of the wastes and to determine if the waste mixture was sufficiently fluid for offloading. Although Essroc and CPRIN personnel said they knew that the TDI matter wastes had to be heated to higher temperatures than the solvent blend wastes, Essroc and CPRIN claim they were unaware that Olin had recommended a maximum safe temperature range of 130 to 140º F for heating the TDI matter wastes. The Essroc facility supervisor said he was under the impression that the TDI matter wastes

could safely be heated to 200º F, whereas CPRIN stated that, although the TDI product should not be heated above 110º F because of possible quality control problems, these concerns did not apply to the TDI matter wastes.

Further, the offloading and steam-heating procedures used by Essroc and CPRIN did not include three critical heating and offloading practices that Olin had used at the Lake Charles plant: steam heating with low-pressure steam, nitrogen sparging while steam heating, and keeping the temperature of the waste mixture below 140º F. Through steam heating with low-pressure steam, the waste mixtures could be heated more slowly and could more easily be maintained at a temperature below the 130 to 140º F threshold recommended by Olin. Performing nitrogen sparging during the steam-heating process would cause the waste mixture at the bottom of the tank car to agitate, which would facilitate a more even distribution of heat throughout the entire waste mixture. The Safety Board concluded that, if Essroc and CPRIN had employed low-pressure steam to heat the wastes, used nitrogen sparging to facilitate even heating throughout the tank car, and maintained the temperature of the wastes below 140º F, the risk of localized overheating and expansion of the waste mixture would have been minimized, and the accident likely would not have occurred.

To determine why Essroc and CPRIN did not employ the procedures used at the Lake Charles plant, the Safety Board asked Olin, Lyondell, Essroc, and CPRIN to describe the information they exchanged about the heating of all TDI waste mixtures, the generation of gas from chemical self-reaction, the expansion of the wastes if overheated, nitrogen sparging, the establishment of temperature limits for the waste mixtures, and other special handling procedures.

Each company provided a different account regarding its responsibilities and the information it either provided or requested. All agreed that a Lake Charles TDI expert met with Essroc and CPRIN personnel at the Essroc plant in spring 1998 to provide instruction on handling and processing TDI matter wastes. The Lake Charles operators, Essroc, and CPRIN agreed that the TDI matter wastes could safely be heated to 125º F, compared to the 90 to 100º F range for the TDI solvent blend wastes. Essroc also acknowledged that the Lake Charles TDI expert had stated that a long, slow heating process was sometimes required to heat the TDI matter wastes. However, neither Essroc nor CPRIN acknowledged that the Lake Charles operators had set a maximum temperature limit or that the Lake Charles operators had recommended using nitrogen sparging and low-pressure steam-heating procedures. The Lake Charles operators, however, maintained that their TDI expert discussed nitrogen sparging, heating with low-pressure steam, and heating limits with Essroc and CPRIN personnel.

As can be seen from this diversity of opinion and recollection as to what was communicated between the producers and receivers in this instance regarding the appropriate procedures for offloading the TDI matter wastes, considerable confusion and misapprehension appears to have been prevalent among those parties that handled the TDI waste mixtures. Given the potentially hazardous nature of TDI matter wastes, such ambiguity is unacceptable.

The investigation also revealed other areas of imprecision. For instance, responsibility for offloading at the Essroc plant seems to have been unclear. Essroc stated that CPRIN was responsible for steam heating the TDI product so that it was sufficiently fluid that it could be pumped to the cement kilns. CPRIN, however, stated that Essroc retained operational authority over the heating and offloading process.

Further, no one at the Essroc plant had comprehensive, written instructions on the offloading procedures to be used. Although Essroc had written procedures for offloading the TDI matter wastes to a fixed blending tank, these procedures did not include details about heating practices, nitrogen sparging, or maximum temperature limits. Then, when Essroc adopted the direct injection procedure in place of blending in a fixed tank, even less information was available. Neither Essroc nor CPRIN had any written procedures for heating and offloading the TDI matter wastes for direct injection of these wastes to the kilns.

Therefore, based on the discrepancies between Essroc's and CPRIN's accounts of their respective roles and responsibilities for handling and disposing of TDI matter wastes and the absence of specific, written procedures for heating and offloading these wastes by direct injection, the Safety Board concluded that Essroc and CPRIN failed to develop and implement appropriate heating and offloading procedures for the TDI matter wastes at the Logansport plant, which resulted in the use of unsafe offloading practices at the plant.

With respect to the Lake Charles operation's procedures, Olin stated, in its response to Safety Board inquiries about whether it had written procedures for heating and offloading TDI wastes, that any written procedures that might have existed had been turned over to Arco (later Lyondell). Lyondell stated that Arco/Lyondell did not have specific, written procedures for on-site blending of the TDI waste mixtures and offloading them from tank cars. Arco/Lyondell had written procedures for blending solvent blend wastes in a fixed tank and then transferring them from the fixed tank into tank cars. These procedures set the temperature and viscosity limits for the solvent blend wastes in the fixed blending tank. However, neither Olin nor Arco/Lyondell had written operating procedures or limitations that addressed the potential for gas generation or product expansion, the maximum temperature and time for heating the TDI wastes, or the maximum product viscosity for offloading tank cars. Therefore, no one at Lake Charles appears to have had comprehensive, written procedures for handling the TDI wastes.

The Safety Board also considers that the implementation of comprehensive, written procedures for loading and offloading chemicals or waste materials exhibiting properties that require special handling must incorporate methods that will detect internal tank conditions and accurately reflect the thermophysical state of all of the material in the tank vessel. The written procedures should specify values or ranges for important material properties such as melting temperature, flash point, maximum allowable product temperature, and viscosity. Further, offloading procedures developed and validated under certain environmental conditions may lead to or cause catastrophic failures or other potential problems in offloading the material when the environmental conditions vary from the baseline conditions.

Partially because there is no written record to which it may refer, the Safety Board cannot decisively determine what information and guidance were provided by the Lake Charles operators to Essroc and CPRIN on heating and offloading TDI matter from tank cars or what consideration, if any, was given to detection of internal tank car conditions that were potentially catastrophic. Nor can the Safety Board be sure what guidance may have been provided by the Lake Charles operators but not implemented by Essroc and CPRIN. Nevertheless, given the differences between the accounts offered by these companies about the guidance given or requested and the lack of comprehensive, written procedures at Lake Charles for handling TDI

wastes, the Safety Board concluded that Olin and Arco (now Lyondell) did not provide Essroc with comprehensive, written information about safe handling procedures for TDI matter wastes.

The Safety Board considers that the producer/shipper and the consignee/end-user of any chemical or waste material have joint responsibility for determining and implementing comprehensive, written procedures for the transfer of any chemical or waste material to and from a tank car, highway cargo tank, or other bulk container when the chemical or waste material exhibits properties that require special handling. Such properties would include those identified with the TDI matter wastes involved in this accident, such as temperature and heating effects, means of self-reaction, and the byproducts of reaction, including the generation of gases and product expansion.

In the Safety Board's view, both parties to the transport of a hazardous material have information vital to its safe transfer. The producer/shipper has detailed knowledge about the properties of the chemical or waste material, while the consignee/end-user has specific information about the transfer facilities at the destination. Ideally, the result of the collaboration between the producer/shipper and consignee/end-user should be the development and implementation of specific, written transfer procedures that address each unique property of the chemical or waste material in the context of the physical layout of a given plant or facility.

The importance and effectiveness of such cooperation is evidenced by what happened when the TDI waste materials had to be moved after the Clymers accident took place. Following the accident at the Essroc plant, Olin and the waste disposal companies that were contracted to unload the remaining tank cars at a transfer facility in Deer Park, Texas, jointly developed comprehensive, written procedures that established viscosity and temperature limits and called for nitrogen sparging. Consequently, the transfer and offloading took place without incident.

Therefore, the National Transportation Safety Board makes the following safety recommendation to the Lyondell Chemical Company:

> Collaborate with applicable producers, shippers, consignees, and end-users in the development and implementation of specific and written procedures for the loading or offloading of any chemical or waste material from a railroad tank car, highway cargo tank, or other bulk transportation vessel when the chemical or waste material exhibits properties that require special handling or processing during the loading or offloading operation. (I-01-05)

The Safety Board also issued safety recommendations to the Federal Railroad Administration, the Research and Special Programs Administration, the Railway Progress Institute, the Association of American Railroads, the Essroc Cement Corporation, the Olin Corporation, and CP Recycling, Inc., and Affiliated Companies. In your response to the recommendation in this letter, please refer to Safety Recommendation I-01-05. If you need additional information, you may call (202) 314-6170.

Acting Chairman CARMODY and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in this recommendation.

[Original Signed]

By: Carol J. Carmody
Acting Chairman

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: March 21, 2002

In reply refer to: R-02-5

Honorable Allan Rutter
Administrator
Federal Railroad Administration
1120 Vermont Avenue, N.W.
Washington, D.C. 20590

On March 17, 2001, about 11:40 p.m. central standard time, westbound National Railroad Passenger Corporation (Amtrak) train No. 5-17, the *California Zephyr*, en route from Chicago, Illinois, to Oakland, California, derailed near Nodaway, Iowa. Amtrak train No. 5-17 consisted of 2 locomotive units and 16 cars. All but the last five cars derailed. No fire or hazardous materials were involved in the accident. The train crew consisted of an engineer and 2 conductors with 13 on-board service personnel. In addition, 241 passengers were on the train. As a result of the derailment, 78 people were injured, including 1 fatal injury.[1]

The National Transportation Safety Board determines that the probable cause of the derailment of Amtrak train No. 5-17 was the failure of the rail beneath the train, due to undetected internal defects. Contributing to the accident was the Burlington Northern and Santa Fe Railway's (BNSF's) lack of a comprehensive method for ensuring that replacement rail is free from internal defects.

Amtrak train No. 5-17 had originated at Chicago, Illinois, at 3:35 p.m. on March 17, 2001, and was destined for Oakland, California. The train crew had originated at Chicago. The engineer on duty at the time of the accident had relieved the original engineer at Ottumwa, Iowa, milepost (MP) 280, about 9:00 p.m.

As the train progressed on its assigned route, the engineer found that the horn/whistle on the lead locomotive failed near Murray, Iowa, MP 370, around 10:21 p.m. He advised the dispatcher for the district of the problem and discussed the failure with the conductor. They decided that the conductor would ride in the second locomotive and activate the horn/whistle on the second locomotive when the train approached and passed through grade crossings. They used this procedure until, at Corning, Iowa, MP 414, the train entered a different train dispatcher's district. The new train dispatcher, upon learning of the malfunctioning horn/whistle, instructed

[1] For additional information, see Railroad Accident Brief—*Derailment of Amtrak Train No. 5-17 on Burlington Northern and Santa Fe Railway Track near Nodaway, Iowa, March 17, 2001* (NTSB/RAB-02/01).

the crew to reduce the speed of the train at the grade crossings rather than using the horn/whistle on the second unit. The conductor of train No. 5-17 came forward and rode in the lead locomotive with the engineer to assist him in observing the crossings. The engineer stated (and event recorder information confirmed) that he began reducing the train's speed at grade crossings. At MP 418.94, the train speed had been 16 mph while passing through a grade crossing. The engineer was accelerating the train during the approach to the accident site (MP 419.92). The event recorder indicated that, at MP 419.90, the train was traveling at 52 mph.

The engineer stated that near MP 419.90 he felt a "tugging" sensation in connection with the train's progress and heard a "grinding, screeching noise," so he made an emergency brake application about 11:40 p.m. When the locomotives came to a stop, the engineer and conductor looked back and realized that the train's cars had uncoupled from the locomotives, and most cars had derailed. The cars were about 1/8 mile behind the stopped locomotives. The engineer radioed the dispatcher and asked him to contact emergency responders. The conductor walked back and surveyed the damage. After reaching the cars, the conductor radioed the engineer and said, "…the wreck look[s] real bad." The conductor found the assistant conductor, and they cared for the passengers. Soon thereafter, local emergency medical service personnel began to arrive and immediately started to evacuate the injured from the train. The emergency response effort was completed by 4:00 a.m., March 18.

A broken rail was discovered at the point of derailment. The broken pieces of rail were reassembled at the scene, and it was determined that they came from a 15-foot 6-inch section of rail that had been installed as replacement rail at this location in February 2001. The replacement had been made because, during a routine scan of the existing rail on February 13, 2001, the BNSF discovered internal defects near MP 419.92. A short section of the continuous welded rail that contained the defects was removed, and a piece of replacement rail was inserted. This rail, referred to as a "plug," was used to replace the defective rail segment. The plug rail did not receive an ultrasonic inspection before or after installation.

After the March 17, 2001, accident, portions of the broken plug rail were sent to the Safety Board laboratory for further analysis. The analysis indicated that the rail had multiple internal defects. Specifically, the laboratory found that the rail failed due to fatigue initiating from cracks associated with the precipitation of internal hydrogen. Cracks associated with the precipitation of internal hydrogen occur in steels due to excessive hydrogen content produced during processing. Therefore, the Safety Board concludes that in February 2001, the BNSF replaced an identified defective rail with a segment of replacement rail that contained undetected multiple internal defects.

Aside from the horn/whistle problem, nothing about Amtrak train No. 5-17's operation as it approached the accident site was unusual. The train was traveling at an appropriate speed for the conditions, and the engineer was operating the train in accordance with BNSF rules and existing signal indications. The "tugging" sensation that the engineer told investigators he felt just before the accident is a typical indicator of a train experiencing a track failure. When the track was examined after the accident, it was found that a rail was broken at the point at which the defective replacement plug rail had been inserted in February 2001. Therefore, the Safety Board concludes that Amtrak train No. 5-17 derailed due to a failure in the plug rail that had been used to replace a defective piece of rail at the accident location.

Typically, replacement rail is rail that has been removed from other track locations for reuse. It is usually visually inspected for obvious surface damage, defects, and excessive wear before installation. Title 49 *Code of Federal Regulations* (CFR) 213.113 provides guidelines that railroads use for replacing defective rail. The regulations, however, focus on operational concerns regarding the defective rail; they do not address how replacement rail should be selected or screened for defects.

Because many internal imperfections cannot be detected through visual inspection, ultrasonically scanning a rail for internal defects is the best means of determining whether a piece of rail is sound and unflawed. No Federal regulations require railroads to verify the quality of the rails used to replace defective rails, and replacement rails are not typically scanned for internal defects before they are used to replace rails that have been identified as defective. Consequently, when they are installed, the replacement rails may actually have internal flaws that have not been discovered, as was the case with the Nodaway plug rail. The Safety Board therefore concludes that using rails that have not been ultrasonically scanned for internal defects before they are installed as replacements for known defective rails may allow the flawed rails to be replaced by other flawed rails.

The Safety Board is not aware of any class I railroad (other than the BNSF since the Nodaway accident) with a procedure for checking the internal quality of rail being used to replace known defective rail. Most railroads rely on the fact that all existing rail must be ultrasonically scanned while in place on the track, in accordance with the requirements at 49 CFR 213.237. Therefore, if a piece of rail has been removed from a track location and stored for future use as replacement rail, a railroad may assume that the replacement rail was scanned while in its previous location and that it passed that inspection. However, this was the process used for the plug rail that failed in the Nodaway accident, and that rail segment was, in fact, defective.

Scanning performed in accordance with 49 CFR 213.237 must be conducted only "at least once every 40 million gross tons (mgt) or once a year, whichever interval is shorter" for class 4 track. In effect, this means that it could take as long as a year for a railroad to scan any given section of rail to detect internal flaws. Although the BNSF exceeds the regulatory criteria and scans such track for internal defects once every 30 days, this still means that, even on the BNSF, defective replacement rail could be in place for as long as a month while rail traffic continues to travel over it. The failure of the Nodaway replacement rail took place within about a month of its being installed at MP 419.92, and the BNSF had not yet routinely scanned this section of rail for internal flaws. Other railroads that do not exceed the regulatory criteria at 49 CFR 213.237 and may take up to a year to scan their trackage are at even greater risk than the BNSF for accidents caused by the failure of defective replacement rails. The Safety Board concludes that relying on scanning schedules as are required under 49 CFR 213.237 to ensure the safety of replacement rail does not provide sufficient protection against the possibility of a replacement rail being internally defective.

Therefore, the National Transportation Safety Board makes the following safety recommendation to the Federal Railroad Administration:

> Require railroads to conduct ultrasonic or other appropriate inspections to ensure that rail used to replace defective segments of existing rail is free from internal defects. (R-02-5)

The Safety Board also issued safety recommendations to the Burlington Northern Santa Fe Corporation and to class I and passenger railroads (except the Burlington Northern and Santa Fe Railway).

Please refer to Safety Recommendation R-02-5 in your reply. If you need additional information, you may call (202) 314-6607.

Chairman BLAKEY, Vice Chairman CARMODY, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in this recommendation.

Original Signed

By: Marion C. Blakey
Chairman

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: March 21, 2002

In reply refer to: R-02-6

Class I and passenger railroads (except the Burlington Northern and Santa Fe Railway)
(see distribution list)

The National Transportation Safety Board is an independent Federal agency charged by Congress with investigating transportation accidents, determining their probable cause, and making recommendations to prevent similar accidents from occurring. We are providing the following information to urge your organization to take action on the safety recommendation in this letter. The Safety Board is vitally interested in this recommendation because it is designed to prevent accidents and save lives.

This recommendation addresses the lack of ultrasonic or other appropriate inspection of replacement rail, either before or after installation, to identify any internal defects. The recommendation is derived from the Safety Board's investigation of the derailment of National Railroad Passenger Corporation (Amtrak) train No. 5-17 on the Burlington Northern and Santa Fe Railway (BNSF) Creston Subdivision, near Nodaway, Iowa, on March 17, 2001, and is consistent with the evidence we found and the analysis we performed.[1] As a result of this investigation, the Safety Board has issued three safety recommendations, one of which is addressed to class I and passenger railroads, including your company. Information supporting this recommendation is discussed below. The Safety Board would appreciate a response from you within 90 days addressing the actions you have taken or intend to take to implement our recommendation.

On March 17, 2001, about 11:40 p.m. central standard time, westbound Amtrak train No. 5-17, the *California Zephyr*, en route from Chicago, Illinois, to Oakland, California, derailed near Nodaway, Iowa. Amtrak train No. 5-17 consisted of 2 locomotive units and 16 cars. All but the last five cars derailed. No fire or hazardous materials were involved in the accident. The train crew consisted of an engineer and 2 conductors with 13 on-board service personnel. In addition, 241 passengers were on the train. As a result of the derailment, 78 people were injured, including 1 fatal injury.

[1] For additional information, see Railroad Accident Brief—*Derailment of Amtrak Train No. 5-17 on Burlington Northern and Santa Fe Railway Track near Nodaway, Iowa, March 17, 2001* (NTSB/RAB-02/01).

The National Transportation Safety Board determines that the probable cause of the derailment of Amtrak train No. 5-17 was the failure of the rail beneath the train, due to undetected internal defects. Contributing to the accident was the BNSF's lack of a comprehensive method for ensuring that replacement rail is free from internal defects.

Amtrak train No. 5-17 had originated at Chicago, Illinois, at 3:35 p.m. on March 17, 2001, and was destined for Oakland, California. The train crew had originated at Chicago. The engineer on duty at the time of the accident had relieved the original engineer at Ottumwa, Iowa, milepost (MP) 280, about 9:00 p.m.

As the train progressed on its assigned route, the engineer found that the horn/whistle on the lead locomotive failed near Murray, Iowa, MP 370, around 10:21 p.m. He advised the dispatcher for the district of the problem and discussed the failure with the conductor. They decided that the conductor would ride in the second locomotive and activate the horn/whistle on the second locomotive when the train approached and passed through grade crossings. They used this procedure until, at Corning, Iowa, MP 414, the train entered a different train dispatcher's district. The new train dispatcher, upon learning of the malfunctioning horn/whistle, instructed the crew to reduce the speed of the train at the grade crossings rather than using the horn/whistle on the second unit. The conductor of train No. 5-17 came forward and rode in the lead locomotive with the engineer to assist him in observing the crossings. The engineer stated (and event recorder information confirmed) that he began reducing the train's speed at grade crossings. At MP 418.94, the train speed had been 16 mph while passing through a grade crossing. The engineer was accelerating the train during the approach to the accident site (MP 419.92). The event recorder indicated that, at MP 419.90, the train was traveling at 52 mph.

The engineer stated that near MP 419.90 he felt a "tugging" sensation in connection with the train's progress and heard a "grinding, screeching noise," so he made an emergency brake application about 11:40 p.m. When the locomotives came to a stop, the engineer and conductor looked back and realized that the train's cars had uncoupled from the locomotives, and most cars had derailed. The cars were about 1/8 mile behind the stopped locomotives. The engineer radioed the dispatcher and asked him to contact emergency responders. The conductor walked back and surveyed the damage. After reaching the cars, the conductor radioed the engineer and said, "…the wreck look[s] real bad." The conductor found the assistant conductor, and they cared for the passengers. Soon thereafter, local emergency medical service personnel began to arrive and immediately started to evacuate the injured from the train. The emergency response effort was completed by 4:00 a.m., March 18.

A broken rail was discovered at the point of derailment. The broken pieces of rail were reassembled at the scene, and it was determined that they came from a 15-foot, 6-inch section of rail that had been installed as replacement rail at this location in February 2001. The replacement had been made because, during a routine scan of the existing rail on February 13, 2001, the BNSF discovered internal defects near MP 419.92. A short section of the continuous welded rail that contained the defects was removed, and a piece of replacement rail was inserted. This rail, referred to as a "plug," was used to replace the defective rail segment. The plug rail did not receive an ultrasonic inspection before or after installation.

After the March 17, 2001, accident, portions of the broken plug rail were sent to the Safety Board laboratory for further analysis. The analysis indicated that the rail had multiple internal defects. Specifically, the laboratory found that the rail failed due to fatigue initiating from cracks associated with the precipitation of internal hydrogen. Cracks associated with the precipitation of internal hydrogen occur in steels due to excessive hydrogen content produced during processing. Therefore, the Safety Board concludes that in February 2001, the BNSF replaced an identified defective rail with a segment of replacement rail that contained undetected multiple internal defects.

Aside from the horn/whistle malfunction, nothing about Amtrak train No. 5-17's operation as it approached the accident site was unusual. The train was traveling at an appropriate speed for the conditions, and the engineer was operating the train in accordance with BNSF rules and existing signal indications. The "tugging" sensation that the engineer told investigators he felt just before the accident is a typical indicator of a train experiencing a track failure. When the track was examined after the accident, it was found that a rail was broken at the point at which the defective replacement plug rail had been inserted in February 2001. Therefore, the Safety Board concludes that Amtrak train No. 5-17 derailed due to a failure in the plug rail that had been used to replace a defective piece of rail at the accident location.

Typically, replacement rail is rail that has been removed from other track locations for reuse. It is usually visually inspected for obvious surface damage, defects, and excessive wear before installation. Title 49 *Code of Federal Regulations* (CFR) 213.113 provides guidelines that railroads use for replacing defective rail. The regulations, however, focus on operational concerns regarding the defective rail; they do not address how replacement rail should be selected or screened for defects.

Because many internal imperfections cannot be detected through visual inspection, ultrasonically scanning a rail for internal defects is the best means of determining whether a piece of rail is sound and unflawed. No Federal regulations require railroads to verify the quality of the rails used to replace defective rails, and replacement rails are not typically scanned for internal defects before they are used to replace rails that have been identified as defective. Consequently, when they are installed, the replacement rails may actually have internal flaws that have not been discovered, as was the case with the Nodaway plug rail. The Safety Board therefore concludes that using rails that have not been ultrasonically scanned for internal defects before they are installed as replacements for known defective rails may allow the flawed rails to be replaced by other flawed rails.

The Safety Board is not aware of any class I railroad (other than the BNSF since the Nodaway accident) with a procedure for checking the internal quality of rail being used to replace known defective rail. Most railroads rely on the fact that all existing rail must be ultrasonically scanned while in place on the track, in accordance with the requirements at 49 CFR 213.237. Therefore, if a piece of rail has been removed from a track location and stored for future use as replacement rail, a railroad may assume that the replacement rail was scanned while in its previous location and that it passed that inspection. However, this was the process used for the plug rail that failed in the Nodaway accident, and that rail segment was, in fact, defective.

Scanning, performed in accordance with requirements at 49 CFR 213.237, is only required to be conducted “at least once every 40 million gross tons (mgt) or once a year, whichever interval is shorter” for class 4 track. In effect, this means that it could take as long as a year for a railroad to scan any given section of rail to detect internal flaws. Although the BNSF exceeds the regulatory criteria and scans such track for internal defects once every 30 days, this still means that, even on the BNSF, defective replacement rail could be in place for as long as a month while rail traffic continues to travel over it. The failure of the Nodaway replacement rail took place within about a month of its being installed at MP 419.92, and the BNSF had not yet routinely scanned this section of rail for internal flaws. Other railroads that do not exceed the regulatory criteria at 49 CFR 213.237 and may take up to a year to scan their trackage are at even greater risk than the BNSF for accidents caused by the failure of defective replacement rails. The Safety Board concludes that relying on scanning schedules as are required under 49 CFR 213.237 to ensure the safety of replacement rail does not provide sufficient protection against the possibility of a replacement rail being internally defective.

On the basis of the Nodaway accident investigation, the Safety Board is recommending that the Federal Railroad Administration require railroads to conduct ultrasonic or other appropriate inspections to ensure that rail used to replace defective segments of existing rail is free from internal defects. The Safety Board would like railroads to act on this important matter without delay.

Therefore, the National Transportation Safety Board makes the following safety recommendation to class I and passenger railroads (except the Burlington Northern and Santa Fe Railway):

> Conduct ultrasonic or other appropriate inspections on all rail used to replace defective segments of existing rail to ensure that the replacement rail is free from internal defects. (R-02-6)

The Safety Board also issued safety recommendations to the Federal Railroad Administration and to the Burlington Northern Santa Fe Corporation. In your response to the recommendation in this letter, please refer to Safety Recommendation R-02-6. If you need additional information, you may call (202) 314-6607.

Chairman BLAKEY, Vice Chairman CARMODY, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in this recommendation.

Original Signed

By: Marion C. Blakey
Chairman

Class I* and Passenger Railroads (except the Burlington Northern and Santa Fe Railway) Distribution List

Mr. David R. Goode
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* The Safety Board is issuing the individual Safety Recommendation R-02-7 concerning replacement rail inspections to the Burlington Northern and Santa Fe Railway Class I railroad, through its parent company, the Burlington Northern Santa Fe Corporation. Consequently, the Safety Board is not including the Burlington Northern and Santa Fe Railway in the distribution list for Safety Recommendation R-02-6.

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National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: March 21, 2002

In reply refer to: R-02-7

Mr. Matthew K. Rose
President
Burlington Northern Santa Fe Corporation
2650 Lou Menk Drive
Fort Worth, Texas 76161

The National Transportation Safety Board is an independent Federal a gency charged by Congress with investigating transportation accidents, determining their probable cause, and making recommendations to prevent similar accidents from occurring. We are providing the following information to urge your organization to take action on the safety recommendation in this letter. The Safety Board is vitally interested in this recommendation because it is designed to prevent accidents and save lives.

This recommendation addresses the lack of ultrasonic or other appropriate inspection of replacement rail, either before or after installation, to identify any internal defects. The recommendation is derived from the Safety Board's investigation of the derailment of National Railroad Passenger Corporation (Amtrak) train No. 5-17 on the Burlington Northern and Santa Fe Railway (BNSF) Creston Subdivision, near Nodaway, Iowa, on March 17, 2001, and is consistent with the evidence we found and the analysis we performed.[1] As a result of this investigation, the Safety Board has issued three safety recommendations, one of which is addressed to the Burlington Northern Santa Fe Corporation. Information supporting this recommendation is discussed below. The Safety Board would appreciate a response from you within 90 days addressing the actions you have taken or intend to take to implement our recommendation.

On March 17, 2001, about 11:40 p.m. central standard time, westbound Amtrak train No. 5-17, the *California Zephyr*, en route from Chicago, Illinois, to Oakland, California, derailed near Nodaway, Iowa. Amtrak train No. 5-17 consisted of 2 locomotive units and 16 cars. All but the last five cars derailed. No fire or hazardous materials were involved in the accident. The train crew consisted of an engineer and 2 conductors with 13 on-board service personnel. In addition, 241 passengers were on the train. As a result of the derailment, 78 people were injured, including 1 fatal injury.

[1] For additional information, see Railroad Accident Brief—*Derailment of Amtrak Train No. 5-17 on Burlington Northern and Santa Fe Railway Track near Nodaway, Iowa, March 17, 2001* (NTSB/RAB-02/01).

The National Transportation Safety Board determines that the probable cause of the derailment of Amtrak train No. 5-17 was the failure of the rail beneath the train, due to undetected internal defects. Contributing to the accident was the BNSF's lack of a comprehensive method for ensuring that replacement rail is free from internal defects.

Amtrak train No. 5-17 had originated at Chicago, Illinois, at 3:35 p.m. on March 17, 2001, and was destined for Oakland, California. The train crew had originated at Chicago. The engineer on duty when the accident occurred had relieved the original engineer at Ottumwa, Iowa, milepost (MP) 280, about 9:00 p.m.

As the train progressed on its assigned route, the engineer found that the horn/whistle on the lead locomotive failed near Murray, Iowa, MP 370, around 10:21 p.m. He advised the dispatcher for the district of the problem and discussed the failure with the conductor. They decided that the conductor would ride in the second locomotive and activate the horn/whistle on the second locomotive when the train approached and passed through grade crossings. They used this procedure until, at Corning, Iowa, MP 414, the train entered a different train dispatcher's district. The new train dispatcher, upon learning of the malfunctioning horn/whistle, instructed the crew to reduce the speed of the train at the grade crossings rather than using the horn/whistle on the second unit. The conductor of train No. 5-17 came forward and rode in the lead locomotive with the engineer to assist him in observing the crossings. The engineer stated (and event recorder information confirmed) that he began reducing the train's speed at grade crossings. At MP 418.94, the train speed had been 16 mph while passing through a grade crossing. The engineer was accelerating the train during the approach to the accident site (MP 419.92). The event recorder indicated that, at MP 419.90, the train was traveling at 52 mph.

The engineer stated that near MP 419.90 he felt a "tugging" sensation in connection with the train's progress and heard a "grinding, screeching noise," so he made an emergency brake application about 11:40 p.m. When the locomotives came to a stop, the engineer and conductor looked back and realized that the train's cars had uncoupled from the locomotives, and most cars had derailed. The cars were about 1/8 mile behind the stopped locomotives. The engineer radioed the dispatcher and asked him to contact emergency responders. The conductor walked back and surveyed the damage. After reaching the cars, the conductor radioed the engineer and said, "…the wreck look[s] real bad." The conductor found the assistant conductor, and they cared for the passengers. Soon thereafter, local emergency medical service personnel began to arrive and immediately started to evacuate the injured from the train. The emergency response effort was completed by 4:00 a.m., March 18.

A broken rail was discovered at the point of derailment. The broken pieces of rail were reassembled at the scene, and it was determined that they came from a 15-foot, 6-inch section of rail that had been installed as replacement rail at this location in February 2001. The replacement had been made because, during a routine scan of the existing rail on February 13, 2001, the BNSF discovered internal defects near MP 419.92. A short section of the continuous welded rail that contained the defects was removed, and a piece of replacement rail was inserted. This rail, referred to as a "plug," was used to replace the defective rail segment. It would have been visually inspected for obvious surface damage, defects, and excessive wear before installation. The plug rail did not receive an ultrasonic inspection before or after installation.

The Safety Board could not reliably determine the source of the plug rail. Two different accounts were given concerning its origin. The local supervisor said the rail came from his inventory of rail and had been in the inventory for several years. Another engineering manager thought that the rail had come from a rail rehabilitation facility in Springfield, Missouri. In either case, the replacement rail would have been rail removed from another track location for reuse.

After the March 17, 2001, accident, portions of the broken plug rail were sent to the Safety Board laboratory for further analysis. The analysis indicated that the rail had multiple internal defects. Specifically, the laboratory found that the rail failed due to fatigue initiating from cracks associated with the precipitation of internal hydrogen. Cracks associated with the precipitation of internal hydrogen occur in steels due to excessive hydrogen content produced during processing. Therefore, the Safety Board concludes that in February 2001, the BNSF replaced an identified defective rail with a segment of replacement rail that contained undetected multiple internal defects.

Aside from the horn/whistle problem, nothing about Amtrak train No. 5-17's operation as it approached the accident site was unusual. The train was traveling at an appropriate speed for the conditions, and the engineer was operating the train in accordance with BNSF rules and existing signal indications. The "tugging" sensation that the engineer told investigators he felt just before the accident is a typical indicator of a train experiencing a track failure. When the track was examined after the accident, it was found that a rail was broken at the point at which the defective replacement plug rail had been inserted in February 2001. Therefore, the Safety Board concludes that Amtrak train No. 5-17 derailed due to a failure in the plug rail that had been used to replace a defective piece of rail at the accident location.

Title 49 *Code of Federal Regulations* (CFR) 213.113 provides guidelines that railroads use for replacing defective rail. The regulations, however, focus on operational concerns regarding the defective rail; they do not address how replacement rail should be selected or screened for defects.

At the time of the accident, the BNSF was revising the directions for replacing defective rail that appear in its *BNSF Engineering Instructions*. The revised BNSF instructions added four new items for its personnel to consider when selecting a replacement rail. None of the new selection instructions would have disqualified the Nodaway replacement rail. According to the engineering instructions, as revised March 1, 2001, the BNSF was aware that defective rail might be replaced with another piece of defective rail. The instructions stated:

> Poor quality rail used for defect removal may itself become defective. One survey found that 17 percent of defects during the month measured were in rails installed to remove previous defects.

Altogether (including the four new instructions), the *BNSF Engineering Instructions* list seven guidelines to help personnel avoid using a defective rail to replace a known defective rail. The guidelines are based on previously determined methods of identifying marginal rail. All use external indicators or previous knowledge of the rail to disqualify the replacement piece. Nothing in the instructions requires BNSF personnel to scan replacement rail for internal defects before installing it in place of a known defective rail.

Because many internal imperfections cannot be detected through visual inspection, ultrasonically scanning a rail for internal defects is the best means of determining whether a piece of rail is sound and unflawed. No Federal regulations require railroads to verify the quality of the rails used to replace defective rails, and replacement rails are not typically scanned for internal defects before they are used to replace rails that have been identified as defective. Consequently, when they are installed, the replacement rails may actually have internal flaws that have not been discovered, as was the case with the Nodaway plug rail. The Safety Board therefore concludes that using rails that have not been ultrasonically scanned for internal defects before they are installed as replacements for known defective rails may allow the flawed rails to be replaced by other flawed rails.

Most railroads rely on the fact that all existing rail must be ultrasonically scanned while in place on the track, in accordance with the requirements at 49 CFR 213.237. Therefore, if a piece of rail has been removed from a track location and stored for future use as replacement rail, a railroad may assume that the replacement rail was scanned while in its previous location and that it passed that inspection. However, this was the process used for the plug rail that failed in the Nodaway accident, and that rail segment was, in fact, defective.

Scanning performed in accordance with 49 CFR 213.237 is only required to be conducted "at least once every 40 million gross tons (mgt) or once a year, whichever interval is shorter" for class 4 track. In effect, this means that it could take as long as a year for a railroad to scan any given section of rail to detect internal flaws. Although the BNSF exceeds the regulatory criteria and scans such track for internal defects once every 30 days, this still means that defective replacement rail could be in place on BNSF class 4 track for as long as a month while rail traffic continues to travel over it. The failure of the Nodaway replacement rail took place within about a month of its being installed at MP 419.92, and the BNSF had not yet routinely scanned this section of rail for internal flaws. The Safety Board concludes that relying on scanning schedules as are required under 49 CFR 213.237 to ensure the safety of replacement rail does not provide sufficient protection against the possibility of a replacement rail being internally defective.

Since the Nodaway accident, the BNSF has required that its personnel scan some replacement rail to be inserted into existing track for internal defects before the replacement is made. However, this requirement applies only to main tracks with passenger train usage and/or train densities of at least 20 mgt per year. Replacements may be made with unscanned rail on all other types of track. Of the BNSF's 29,043 miles of main track, approximately 9,157 track miles are on passenger routes and 10,126 track miles are on nonpassenger routes that carry more than 20 mgt per year. In other words, approximately 9,760 miles, or 34 percent, of BNSF main track is not subject to pre-replacement scanning of replacement rails. The Safety Board considers that limiting the scanning requirement to main track that carries passenger trains or has 20 mgt or more traffic per year leaves a substantial amount of trackage at risk for having defective replacement rails inserted into existing track. The internal defects of such rails could cause rail failures, possibly leading to derailments or other types of accidents, before the defects are detected by the railroad through its routine rail scanning procedures, as required under 49 CFR 213.237.

Therefore, the National Transportation Safety Board makes the following safety recommendation to the Burlington Northern Santa Fe Corporation:

> Implement a permanent policy of inspecting for internal defects, using ultrasonic or other appropriate means, any rail used to replace a defective segment of existing rail. (R-02-7)

The Safety Board also issued safety recommendations to the Federal Railroad Administration and to class I and passenger railroads (except the Burlington Northern and Santa Fe Railway). In your response to the recommendation in this letter, please refer to Safety Recommendation R-02-7. If you need additional information, you may call (202) 314-6607.

Chairman BLAKEY, Vice Chairman CARMODY, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in this recommendation.

Original Signed

By: Marion C. Blakey
Chairman

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: March 21, 2002

In reply refer to: R-02-8 through -12

Mr. A. R. Carpenter
President and Chief Executive Officer
CSX Transportation, Inc.
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The National Transportation Safety Board is an independent Federal agency charged by Congress with investigating transportation accidents, determining their probable cause, and making recommendations to prevent similar accidents from occurring. We are providing the following information to urge your organization to take action on the safety recommendations in this letter. The Safety Board is vitally interested in these recommendations because they are designed to prevent accidents and save lives.

These recommendations address (1) the determination and designation of maximum authorized train speeds with sufficient safety margins to ensure that a train can be stopped by the air brake system alone, and (2) locomotive engineer support and training. The recommendations are derived from the Safety Board's investigation of the January 30, 2000, derailment of CSX Transportation (CSXT) coal train V986-26 near Bloomington, Maryland, and are consistent with the evidence we found and the analysis we performed. As a result of this investigation, the Safety Board has issued five safety recommendations, three of which are addressed specifically to CSXT, and two of which are addressed to all class I railroads, including CSXT. Information supporting the recommendations is discussed below. The Safety Board would appreciate a response from you within 90 days addressing the actions you have taken or intend to take to implement our recommendations.

About 7:00 a.m. on January 30, 2000, eastbound loaded CSXT coal train V986-26 lost effective braking while descending a section of track known as "17-mile grade" from Altamont to Bloomington, Maryland, and derailed 76 of its 80 "bathtub" high-side gondola cars when the train failed to negotiate curves at excessive speed. The derailed cars destroyed a nearby occupied residence, killing a 15-year-old boy and seriously injuring his mother. Three other occupants of the residence escaped with little or no injury. Track and equipment damages were estimated to be in excess of $3.2 million. There was no resulting fire or hazardous materials release.[1]

[1] For more information, see National Transportation Safety Board, *Derailment of CSX Transportation Coal Train V986-26 at Bloomington, Maryland, January 30, 2000*, Railroad Accident Report NTSB/RAR-02/02 (Washington, D.C.: NTSB, 2002).

The National Transportation Safety Board determined that the probable cause of the January 30, 2000, derailment of CSXT train V986-26 near Bloomington, Maryland, was the railroad's practice of including dynamic braking in determining maximum authorized speed without providing the engineer with real-time information on the status of the dynamic braking system.

To a large extent, train speeds and train handling are determined empirically within the limitations of the track structure and signal or train control systems. As with the maximum authorized speed through the accident area, most speed limits have not changed over a long period, particularly speed limits for common trains like coal trains, even though the weight of trains has steadily increased over time. CSXT has been able to maintain relatively high speeds despite increasing train weight because of the emphasis on and continued improvement of locomotive dynamic braking.

In this accident, dynamic braking on the two trailing locomotive units, while available, could not be activated because of the defective multiple-unit cable between the first and second locomotive units. Because he did not have the benefit of full dynamic braking, the engineer had to increase the air brake application beyond what normally would have been expected in order to control speed. By so doing, he unwittingly overheated the tread-brake system. Further, the maximum authorized speed for the accident grade had been established based on the assumed availability and use of dynamic braking. Judging from the CSXT's experience of successfully negotiating 17-mile grade at the maximum authorized speed, the combination of dynamic and air braking was, in fact, adequate to hold a train at or under the established maximum authorized speed as the train progressed down the grade. The Safety Board concluded that if all the available dynamic braking could have been activated on the accident train, the derailment probably would not have occurred.

Unfortunately, problems can occur when, as in this accident, the dynamic braking system functions only partially or suddenly and unexpectedly fails when the train is moving too fast to be stopped by the air brakes alone. Calculations and dynamometer testing confirmed that CSXT eastbound loaded coal trains on 17-mile grade could not be controlled or stopped at the maximum authorized speed without the use of significant dynamic braking. The Safety Board concluded that by using the effects of dynamic braking in its speed calculations, CSXT established a maximum authorized speed over and down 17-mile grade that was too high to ensure that heavily loaded trains could be stopped using air brakes alone.

The lead locomotive unit had no device for checking the real-time condition of the dynamic brakes on the trailing locomotive units (or the signal continuity through the multiple-unit cable), nor was such a device required at the time of the accident. Nor did the company have a requirement that the dynamic braking system be tested before or during use to determine how well it was functioning. After the accident, CSXT instituted a running dynamic brake test procedure for its Mountain Subdivision.

As a result of its investigation of the runaway and subsequent derailment of a Southern Pacific Transportation Company train in San Bernardino, California, in 1989, the Safety Board issued the following recommendation to the Federal Railroad Administration (FRA) regarding dynamic braking:

R-90-23
Study, in conjunction with Association of American Railroads, the feasibility of developing a positive method to indicate to the operating engineer in the cab of the controlling locomotive unit the condition of the dynamic brakes on all units in the train.

The Safety Board classified this recommendation "Closed—Unacceptable Action/Superseded" after its investigation of a runaway Union Pacific train at Kelso, California. After that accident, the Safety Board issued the following safety recommendation to the FRA:

R-98-6
Require railroads to ensure that all locomotives with dynamic braking be equipped with a device in the cab of the controlling locomotive unit to indicate to the operating engineer the real-time condition of the dynamic brakes on each trailing unit.

This recommendation was classified "Open—Acceptable Response" on January 11, 2000.

The FRA has included in the new power brake regulations (49 *Code of Federal Regulations* 232.109) the following dynamic braking requirements:

(a) A locomotive engineer shall be informed in writing of the operational status of the dynamic brakes on all locomotive units in the consist at the initial terminal or point of origin for a train and at other locations where a locomotive engineer first takes charge of a train.

(g) All locomotives equipped with dynamic brakes and ordered on or after August 1, 2002, or placed in service for the first time on or after April 1, 2004, shall be designed to:

(1) Test the electrical integrity of the dynamic brake at rest; and

(2) Display the available total train dynamic brake retarding force at various speed increments in the cab of the controlling (lead) locomotive.

(h) All rebuilt locomotives equipped with dynamic brakes and placed in service on or after April 1, 2004, shall be designed to:

(1) Test the electrical integrity of the dynamic brake at rest; and

(2) Display either the train deceleration rate or the available total train dynamic brake retarding force at various speed increments in the cab of the controlling (lead) locomotive.

While the new regulation does not require a dynamic braking display for each trailing locomotive unit, as recommended by the Safety Board, a total real-time dynamic braking effort display as described above may be as useful and acceptable. The Safety Board is also pleased to note that the accelerometer will be used in conjunction with the FRA regulation that will require a train descending a grade of 1 percent or greater to be immediately stopped if it exceeds the maximum authorized speed by more than 5 mph. Therefore, the Board has reclassified Safety Recommendation R-98-6 to the FRA “Closed—Acceptable Alternate Action.”

At the time of the accident, the maximum authorized speed from Swanton (milepost [MP] 219.4) to Bloomington (MP 206.2) was 25 mph. CSXT lowered the maximum authorized speed to 20 mph after the accident in an attempt to create a safe speed. CSXT Rule 34-D requires that, on descending grades of 1 percent or more, a train must be stopped using an emergency brake application if the train’s speed reaches 5 mph more than the maximum speed permitted for that train. Thus, even under the reduced postaccident maximum speed of 20 mph, the engineer could still attain 25 mph before attempting to stop the train.

According to commonly accepted air brake industry standards, a train with cars that have 36-inch diameter wheels, such as the accident train, should not exceed an average braking horsepower (bhp) of 30. The accident train had such a bhp, but only when it was traveling about 15 mph. At 20 mph, its bhp was 49.54; and at 30 mph, its bhp was 64.40. The large disparity in bhp between the recommended 30 and the actual number the accident train had at its maximum authorized speed translates into significant increases in the heat generated at the interface between the brake shoe and wheel tread. The increases in heat, in turn, degrade the brake shoes and cause heat fade and the loss of molecular adhesion, resulting in a catastrophic loss of retardation and braking power—a runaway train.

Actual brake shoe force measurements were taken for each brake application on identical coal cars on August 8, 2000. Using these shoe forces, the bhp calculations were then substantiated by dynamometer tests performed on August 22, 2000. These test results also indicated that the heat from the applied accident train brakes had reached the critical point about the time the train began to pass through Swanton Flats, MP 219.4, only about 3.6 miles into 17-mile grade. By that time, the temperature of the brake shoes/wheels exceeded the thermal limit of the brake shoes and resulted in a loss of braking power.

The dynamometer tests validated the theoretical calculations. The calculations and dynamometer tests showed that the maximum authorized speed of 25 mph was too high and that, in fact, any speed above 15 mph was too high to allow the train to be brought to a stop by the air brakes alone. The maximum authorized speed down 17-mile grade should probably have been no greater than 15 mph to ensure safe operation in the event of either partial or full dynamic brake failure or an unintended release of the air brake.

CSXT does actively update its train handling practices as train equipment improves. To a large extent, it does the updating by using computer simulators, such as a train dynamics analyzer. The analyzer is used to match methods of train handling with current and proposed maximum authorized speeds; however, no software is yet capable of replicating the loss of braking caused by heat fade. (Such software is under development.) Since a train dynamics analyzer cannot replicate heat fade, a simulator may indicate that a train can be stopped when, in reality, it may be unstoppable. Running an actual train on steep grades and applying the brakes until heat fade occurs is dangerous and expensive and is therefore not practical. The most available current methods of determining the maximum authorized speed are by calculation or by using dynamometers; however, most railroads use neither.

As already noted, the Safety Board has previously investigated runaway train accidents at San Bernardino and Kelso, California, involving the Southern Pacific and the Union Pacific railroads. There have been similar incidents on the BNSF Railway on Cajon Pass. All these accidents and incidents involved, as does the Bloomington accident, the dependence on and sudden loss of dynamic braking. The Safety Board is concerned that maximum authorized speeds enabling a train to stop by the air brake system alone are not, and have not been, audited or re-evaluated by the major carriers as frequently as necessary over time as trains have become heavier and braking systems have changed. Therefore, the Safety Board believes that the class I railroads should calculate steep-grade maximum authorized speeds to ensure that trains can be stopped by use of the air brake system alone and should establish procedures to periodically revise maximum authorized speeds as necessary.

While the Bloomington accident engineer's actions do not appear to have directly caused or contributed to the accident, some of his actions, or some of his failures to act, reflect upon the efficacy of his supervision, training, and support.

The engineer had more than 29 years of railroad experience at the time of the accident. He was well regarded by railroad management and coworkers as a "senior" engineer. He had been in engine service since 1976 and had made numerous runs along the Grafton to Cumberland route. He had come back to road service on January 9, 2000, a few weeks before the accident. He had just had his last rules class and test 3 days before the accident. He had completed 2 days of recertification[2] training (49 CFR Part 240) at the CSXT Training Center, Cumberland, Maryland, on May 4, 1999, which consisted of classroom presentations and tests. And yet, in this accident, the engineer's train handling was not optimal.

According to FRA inspectors, CSXT operating officers, and CSXT engineers with knowledge of and experience with 17-mile grade, it is possible to control a loaded coal train headed by three modern locomotive units with a 12-pound or less brake pipe reduction and light throttle or dynamic brake modulation. Earlier in the trip, the helper engineer had noted that the train engineer had used more air brake than was normal or routine. The accident engineer stated several times that he attributed his use of more air brake than usual to the wet snow and icy rail; however, his need to power against a 17-pound reduction with up to a 6th notch of throttle belies this contention.

The engineer said he was afraid that the train would stall at Swanton Flats if he did not power against the brakes. Thus, he should have realized that the brakes were effective and not affected at that time by snow or ice. An engineer who was fully situationally aware and who understood the grade and the newer locomotives would likely have been aware that something was wrong long before the point where the train could not be controlled with customary train handling.

CSXT rules state, "When necessary to apply power descending long heavy grades, trains must not be pulled[3] for a distance greater than 2 miles if the brake pipe reduction is 18 pounds

[2] Recertification is not the same as requalification.

[3] In order for the train to be pulled regardless of whether the train brakes are applied, the locomotives must be in the power mode.

[psi] or greater." According to the event recorder, the engineer had steadily increased the air brake application for more than 10 minutes, until he had a 17-pound reduction of the brake pipe[4] at MP 220.12 (Swanton) at a speed of 24 mph. He maintained the 17-pound reduction for the next 9 minutes at a speed of 24 mph. It is significant that he powered against this 17-pound reduction through Swanton for about 5 minutes and 2 miles, at one point reaching the 6th notch on the throttle. He further reduced the brake pipe to 18 pounds at MP 216.46 at a speed of 28 mph.

Thus the engineer had been operating at the limit or just short of the 18-pound limit, and the brakes had probably already reached the thermal point of no return at the speed the train was moving. He continued to make progressive 1-pound reductions for about the next 4 minutes as the speed of the train increased to 34 mph, when he finally placed the brakes in emergency. Had the engineer gone into emergency shortly after reaching the 18-pound reduction, as required by rule, he probably would not have been able to stop, since the train's brakes were probably already beyond the critical thermal limit.

The actions of the engineer, and the effects of those actions, point out a problem with the CSXT "18-pound" rule. As written, the rule is inadequate to ensure that an engineer does not, as the accident engineer did, power against his brakes at a speed that is likely to cause excessive heat generation and loss of control. All the calculations for bhp are based on the factor of speed or velocity—the greater the speed, the greater the bhp and heat energy generated by the friction brakes. The CSXT rule does not include a critical limit for speed. The Safety Board concluded that, because the CSXT rule regarding powering against the brakes does not address train speed, it is inadequate to ensure that an engineer does not exceed the bhp and heat energy limitations of the tread brake system and thereby create conditions that can lead to a runaway train.

The engineer said that he had transferred from a yard to a road assignment only a few weeks before the derailment. Consequently, the general road foreman told the engineer that he could have a pilot for two roundtrips. For the engineer's first trip on the assignment, a pilot was provided for the westbound leg, from Cumberland to Grafton (uphill, in the opposite direction of the accident train). Because the crew returned to Cumberland by taxi, the engineer did not make an eastbound trip (which would have taken him down 17-mile grade) with the pilot.

The engineer said that when he was called for his second trip, he asked that a pilot accompany him on the return to Cumberland. But, he said, a crew caller told him that the crew caller and the lead crew caller would decide whether the engineer needed a pilot and, if so, would provide one. No pilot was provided.

Additionally, according to the engineer and to CSXT records, no supervisor had ridden with the engineer while he operated a train down 17-mile grade to monitor his performance or to provide specific train handling instruction and guidance, even though this area was a critical train handling portion of the railroad. And while the engineer had made one trip down the grade as an observer and had operated a train on eight trips down 17-mile grade in the weeks preceding the accident (most of them with loaded coal trains), neither he nor his supervisors could know for

[4] The brake pipe pressure is 90 psi minus the total reduction. In this case a 17-pound reduction will result in a brake pipe pressure of 73 psi.

certain whether his train handling technique was appropriate or whether it offered some safety margin in case of an unforeseen event.

After the engineer placed the train brakes in emergency with the automatic brake handle, he did not confirm that the emergency application had propagated to the end of the train until a minute and a half later when he saw the head-end display showing 0 psi pressure for the train's end-of-train device (EOT). Had he activated the EOT emergency brake application switch immediately after initiating the emergency application, he would have ensured that the emergency application had reached the end of the train.

Immediately throwing the EOT switch not only propagates the brake application more rapidly because the release of air pressure comes from both ends of the train rather than just the head end, but it also ensures full propagation even if a kink or other obstruction is blocking the trainline. Thus, the prudent action would have been to immediately flip the EOT emergency brake switch. The needless time taken to confirm that the emergency propagation was complete could, under some circumstances, have been critical. In this case, because the engineer had already exceeded the thermal limit of the brakes by the time that he placed the brakes in emergency, his failure to immediately initiate an EOT emergency application became moot.

The engineer said he had been trained to use the two-way EOT emergency switch only if the EOT was not showing 0 psi after an emergency brake application. Since using the switch causes no damage to any equipment on the train while offering the advantages of a quicker and more thorough response, the Safety Board fails to see the benefit in restricting its use to what is, in effect, a backup system. CSXT agrees and has an automatic two-way emergency EOT switch on all new locomotives. In addition, CSXT offers instruction in the use of the switch in its engineer classes and, in its operating rules, requires immediate use of the switch in an emergency.

During the runaway, the train crew was unable to contact the dispatcher but was able to contact the railroad operator at West Keyser, Virginia, as the train passed Bond at MP 212.6. The engineer attributed his inability to contact the dispatcher to the fact that the radio on the ex-Conrail lead locomotive was different from the radios found on the CSXT locomotives that he more commonly operated. Postaccident testing of the engineer's radio and subsequent investigation revealed that the radio worked as designed.

U.S. railroads use five basic styles of locomotive radios, each of which is compatible with the others, regardless of railroad. Except for superficial details such as dials, touch pads, and channel display, all railroad radios are similar; that is, they use the same frequencies or channels. Timetable instructions list the particular channels for emergency use and/or for calls to the dispatcher. Had the engineer properly set the channel for the dispatcher and then pushed the correct keypad number—either "9" for emergency or "5" for the dispatcher—he would have reached the dispatcher.

The Safety Board concluded that CSXT failed to train and oversee the engineer sufficiently and effectively as evidenced by (1) management's failure to provide the engineer with a pilot when requested, (2) management's failure to fully evaluate the engineer over the critical portion of the railroad where the accident took place, (3) the engineer's failure to use the

EOT emergency brake switch, (4) the engineer's imprudent use of power during brake application, and (5) the engineer's reported inability to use the radio to contact the dispatcher.

The National Transportation Safety Board therefore makes the following safety recommendations to CSX Transportation, Inc.:

> Systematically ensure that engineers are provided with pilots as appropriate and that locomotive engineers are fully evaluated over the whole of their territories, particularly in critical areas of train handling such as steep grades. (R-02-8)
>
> Revise your locomotive engineer training and requalification programs as necessary to ensure that they address (1) the emergency use of the two-way end-of-train emergency switch, (2) the proper use of power during a brake application to prevent heat fade and loss of braking, and (3) the use of all styles of locomotive radios, especially their use during emergency situations to call the dispatcher. (R-02-9)
>
> Modify CSX Transportation Rule 3.3.7, *Speed Control on Descending Grade*, Paragraph C, "Use of Power on Heavy Descending Grades," to impose a speed limit in addition to the maximum distance and brake pipe reduction currently imposed to prevent excessive heat generation, heat fade, and loss of braking ability. (R-0-10)
>
> Calculate and document steep-grade maximum authorized speeds to ensure that trains can be stopped by use of the air brake system alone. (R-02-11)
>
> Establish procedures to revise steep-grade maximum authorized speeds as necessary. (R-02-12)

Safety Recommendations R-02-11 and -12 were also issued to all class I railroads. In your response to this letter, please refer to Safety Recommendations R-02-8 through -12. If you need additional information, you may call (202) 314-6607.

Chairman BLAKEY, Vice Chairman CARMODY, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

Original Signed

By: Marion C. Blakey
Chairman

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: March 21, 2002

In reply refer to: R-02-11 and -12

To All Class I Railroads (See attached list)

The National Transportation Safety Board is an independent Federal agency charged by Congress with investigating transportation accidents, determining their probable cause, and making recommendations to prevent similar accidents from occurring. We are providing the following information to urge your organization to take action on the safety recommendations in this letter. The Safety Board is vitally interested in these recommendations because they are designed to prevent accidents and save lives.

These recommendations address the determination and designation of maximum authorized train speeds with sufficient safety margins to ensure that a train can be stopped by the air brake system alone. The recommendations are derived from the Safety Board's investigation of the January 30, 2000, derailment of CSX Transportation (CSXT) coal train V986-26 near Bloomington, Maryland, and are consistent with the evidence we found and the analysis we performed. As a result of this investigation, the Safety Board has issued five safety recommendations, two of which are addressed to all class I railroads. Information supporting the recommendations is discussed below. The Safety Board would appreciate a response from you within 90 days addressing the actions you have taken or intend to take to implement our recommendations.

About 7:00 a.m. on January 30, 2000, eastbound loaded CSXT coal train V986-26 lost effective braking while descending a section of track known as "17-mile grade" from Altamont to Bloomington, Maryland, and derailed 76 of its 80 "bathtub" high-side gondola cars when the train failed to negotiate curves at excessive speed. The derailed cars destroyed a nearby occupied residence, killing a 15-year-old boy and seriously injuring his mother. Three other occupants of the residence escaped with little or no injury. Track and equipment damages were estimated to be in excess of $3.2 million. There was no resulting fire or hazardous materials release.[1]

As the train began it uncontrollable descent down 17-mile grade, the engineer placed the train in emergency using the automatic brake valve handle. He did not use the switch in the cab that would have activated an emergency application from the two-way end-of-train device (EOT) on the rear of the train. He said that he noted the EOT was indicating a train line pressure of 0 psi about a minute and a half after he had made the emergency application and that he therefore felt no need to activate the switch.

[1] For more information, see National Transportation Safety Board, *Derailment of CSX Transportation Coal Train V986-26 at Bloomington, Maryland, January 30, 2000*, Railroad Accident Report NTSB/RAR-02/02 (Washington, D.C.: NTSB, 2002).

Immediately throwing the EOT switch not only propagates the brake application more rapidly because the release of air pressure comes from both ends of the train rather than just the head end, but it also ensures full propagation even if a kink or other obstruction is blocking the trainline. Thus, the prudent action would have been to immediately flip the EOT emergency brake switch. The needless time taken to confirm that the emergency propagation was complete could, under some circumstances, have been critical.

The engineer said he had been trained to use the two-way EOT emergency switch only if the EOT was not showing 0 psi after an emergency brake application. Since using the switch causes no damage to any equipment on the train while offering the advantages of a quicker and more thorough response, the Safety Board fails to see the benefit in restricting its use to what is, in effect, a backup system. CSXT agrees and has an automatic two-way emergency EOT switch on all new locomotives. In addition, CSXT offers instruction in the use of the switch in its engineer classes and, in its operating rules, requires immediate use of the switch in an emergency.

The engineer said that after he applied the emergency brakes and it became apparent that the train was uncontrollable, he attempted to contact the dispatcher on the locomotive radio but was unable to do so because "[this was] a Conrail radio, and evidently they're not compatible with ours [CSXT]." Postaccident testing of the engineer's radio and subsequent investigation revealed that the radio worked as designed.

U.S. railroads use five basic styles of locomotive radios, each of which is compatible with the others, regardless of railroad. Except for superficial details such as dials, touch pads, and channel display, all railroad radios are similar; that is, they use the same frequencies or channels. Timetable instructions list the particular channels for emergency use and/or for calls to the dispatcher. Had the engineer properly set the channel for the dispatcher and then pushed the correct keypad number—either "9" for emergency or "5" for the dispatcher—he would have reached the dispatcher.

As a result of the engineer's failure to activate the two-way EOT and his apparent inability to effectively use the locomotive radio, the Safety Board has recommended to CSXT that it revise its locomotive engineer training and requalification programs as necessary to, among other objectives, ensure that those programs address both the emergency use of the two-way EOT emergency switch and the use of all styles of locomotive radios, especially their use during emergency situations to call the dispatcher. Because of the sharing of locomotive power that commonly occurs among railroads, the Safety Board encourages all class I railroads to review their own train crew training and evaluation programs to ensure that crews are trained and tested in the use of the two-way EOT emergency switch and the various types of locomotive radios they may encounter.

The National Transportation Safety Board determined that the probable cause of the January 30, 2000, derailment of CSXT train V986-26 near Bloomington, Maryland, was the railroad's practice of including dynamic braking in determining maximum authorized speed without providing the engineer with real-time information on the status of the dynamic braking system.

To a large extent, train speeds and train handling are determined empirically within the limitations of the track structure and signal or train control systems. As with the maximum authorized speed through the accident area, most speed limits have not changed over a long period, particularly speed limits for common trains like coal trains, even though the weight of trains has steadily increased over time. CSXT has been able to maintain relatively high speeds despite increasing train weight because of the emphasis on and continued improvement of locomotive dynamic braking.

In this accident, dynamic braking on the two trailing locomotive units, while available, could not be activated because of the defective multiple-unit cable between the first and second locomotive units. Because he did not have the benefit of full dynamic braking, the engineer had to increase the air brake application beyond what normally would have been expected in order to control speed. By so doing, he unwittingly overheated the tread-brake system. Further, the maximum authorized speed for the accident grade had been established based on the assumed availability and use of dynamic braking. Judging from the CSXT's experience of successfully negotiating 17-mile grade at the maximum authorized speed, the combination of dynamic and air braking was, in fact, adequate to hold a train at or under the established maximum authorized speed as the train progressed down the grade. The Safety Board concluded that if all the available dynamic braking could have been activated on the accident train, the derailment probably would not have occurred.

Unfortunately, problems can occur when, as in this accident, the dynamic braking system functions only partially or suddenly and unexpectedly fails when the train is moving too fast to be stopped by the air brakes alone. Calculations and dynamometer testing confirmed that CSXT eastbound loaded coal trains on 17-mile grade could not be controlled or stopped at the maximum authorized speed without the use of significant dynamic braking. The Safety Board concluded that by using the effects of dynamic braking in its speed calculations, CSXT established a maximum authorized speed over and down 17-mile grade that was too high to ensure that heavily loaded trains could be stopped using air brakes alone.

The lead locomotive unit had no device for checking the real-time condition of the dynamic brakes on the trailing locomotive units (or the signal continuity through the multiple-unit cable), nor was such a device required at the time of the accident. Nor did the company have a requirement that the dynamic braking system be tested before or during use to determine how well it was functioning. After the accident, CSXT instituted a running dynamic brake test procedure for its Mountain Subdivision.

As a result of its investigation of the runaway and subsequent derailment of a Southern Pacific Transportation Company train in San Bernardino, California, in 1989, the Safety Board issued the following recommendation to the Federal Railroad Administration (FRA) regarding dynamic braking:

> <u>R-90-23</u>
> Study, in conjunction with Association of American Railroads, the feasibility of developing a positive method to indicate to the operating engineer in the cab of the controlling locomotive unit the condition of the dynamic brakes on all units in the train.

The Safety Board classified this recommendation "Closed—Unacceptable Action/Superseded" after its investigation of a runaway Union Pacific train at Kelso, California. After that accident, the Safety Board issued the following safety recommendation to the FRA:

> R-98-6
> Require railroads to ensure that all locomotives with dynamic braking be equipped with a device in the cab of the controlling locomotive unit to indicate to the operating engineer the real-time condition of the dynamic brakes on each trailing unit.

This recommendation was classified "Open—Acceptable Response" on January 11, 2000.

The FRA has included in the new power brake regulations (49 *Code of Federal Regulations* 232.109) the following dynamic braking requirements:

> (a) A locomotive engineer shall be informed in writing of the operational status of the dynamic brakes on all locomotive units in the consist at the initial terminal or point of origin for a train and at other locations where a locomotive engineer first takes charge of a train.
>
> (g) All locomotives equipped with dynamic brakes and ordered on or after August 1, 2002, or placed in service for the first time on or after April 1, 2004, shall be designed to:
>
> > (1) Test the electrical integrity of the dynamic brake at rest; and
> >
> > (2) Display the available total train dynamic brake retarding force at various speed increments in the cab of the controlling (lead) locomotive.
>
> (h) All rebuilt locomotives equipped with dynamic brakes and placed in service on or after April 1, 2004, shall be designed to:
>
> > (1) Test the electrical integrity of the dynamic brake at rest; and
> >
> > (2) Display either the train deceleration rate or the available total train dynamic brake retarding force at various speed increments in the cab of the controlling (lead) locomotive.

While the new regulation does not require a dynamic braking display for each trailing locomotive unit, as recommended by the Safety Board, a total real-time dynamic braking effort display as described above may be as useful and acceptable. The Safety Board is also pleased to note that the accelerometer will be used in conjunction with the FRA regulation that will require a train descending a grade of 1 percent or greater to be immediately stopped if it exceeds the maximum authorized speed by more than 5 mph. Therefore, the Board has reclassified Safety Recommendation R-98-6 to the FRA "Closed—Acceptable Alternate Action."

At the time of the accident, the maximum authorized speed from Swanton (milepost [MP] 219.4) to Bloomington (MP 206.2) was 25 mph. CSXT lowered the maximum authorized speed to 20 mph after the accident in an attempt to create a safe speed. CSXT Rule 34-D requires that, on descending grades of 1 percent or more, a train must be stopped using an emergency brake application if the train's speed reaches 5 mph more than the maximum speed permitted for that train. Thus, even under the reduced postaccident maximum speed of 20 mph, the engineer could still attain 25 mph before attempting to stop the train.

According to commonly accepted air brake industry standards, a train with cars that have 36-inch diameter wheels, such as the accident train, should not exceed an average braking horsepower (bhp) of 30. The accident train had such a bhp, but only when it was traveling about 15 mph. At 20 mph, its bhp was 49.54; and at 30 mph, its bhp was 64.40. The large disparity in bhp between the recommended 30 and the actual number the accident train had at its maximum authorized speed translates into significant increases in the heat generated at the interface between the brake shoe and wheel tread. The increases in heat, in turn, degrade the brake shoes and cause heat fade and the loss of molecular adhesion, resulting in a catastrophic loss of retardation and braking power—a runaway train.

Actual brake shoe force measurements were taken for each brake application on identical coal cars on August 8, 2000. Using these shoe forces, the bhp calculations were then substantiated by dynamometer tests performed on August 22, 2000. These test results also indicated that the heat from the applied accident train brakes had reached the critical point about the time the train began to pass through Swanton Flats, MP 219.4, only about 3.6 miles into 17-mile grade. By that time, the temperature of the brake shoes/wheels exceeded the thermal limit of the brake shoes and resulted in a loss of braking power.

The dynamometer tests validated the theoretical calculations. The calculations and dynamometer tests showed that the maximum authorized speed of 25 mph was too high and that, in fact, any speed above 15 mph was too high to allow the train to be brought to a stop by the air brakes alone. The maximum authorized speed down 17-mile grade should probably have been no greater than 15 mph to ensure safe operation in the event of either partial or full dynamic brake failure or an unintended release of the air brake.

CSXT does actively update its train handling practices as train equipment improves. To a large extent, it does the updating by using computer simulators, such as a train dynamics analyzer. The analyzer is used to match methods of train handling with current and proposed maximum authorized speeds; however, no software is yet capable of replicating the loss of braking caused by heat fade. (Such software is under development.) Since a train dynamics analyzer cannot replicate heat fade, a simulator may indicate that a train can be stopped when, in reality, it may be unstoppable. Running an actual train on steep grades and applying the brakes until heat fade occurs is dangerous and expensive and is therefore not practical. The most available current methods of determining the maximum authorized speed are by calculation or by using dynamometers; however, most railroads use neither.

As already noted, the Safety Board has previously investigated runaway train accidents at San Bernardino and Kelso, California, involving the Southern Pacific and the Union Pacific railroads. There have been similar incidents on the BNSF Railway on Cajon Pass. All these accidents and incidents involved, as does the Bloomington accident, the dependence on and sudden loss of dynamic braking. The Safety Board is concerned that maximum authorized speeds enabling a train to stop by the air brake system alone are not, and have not been, audited or re-evaluated by the major carriers as frequently as necessary over time as trains have become heavier and braking systems have changed.

The National Transportation Safety Board therefore makes the following safety recommendations to all class I railroads:

> Calculate and document steep-grade maximum authorized speeds to ensure that trains can be stopped by use of the air brake system alone. (R-02-11)
>
> Establish procedures to revise steep-grade maximum authorized speeds as necessary. (R-02-12)

The Safety Board also made safety recommendations to CSX Transportation. In your response to this letter, please refer to Safety Recommendations R-02-11 and -12. If you need additional information, you may call (202) 314-6607.

Chairman BLAKEY, Vice Chairman CARMODY, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

Original Signed

By: Marion C. Blakey
Chairman

Class I Railroads Distribution List

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Chairman
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(Separate letter sent to CSXT)
Mr. A. R. Carpenter
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Mr. Robert J. Ritchie
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Mr. Landon H. Rowland
President and Chief Executive Officer
The Kansas City Southern Railway Company
Stilwell Financial, Inc.
920 Main Street, 21st floor
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Mr. Richard K. Davidson
Chief Executive Officer
Union Pacific Corporation
1416 Dodge Street
Omaha, Nebraska 68179

National Transportation Safety Board
Washington, D.C. 20594

Safety Recommendation

Date: March 29, 2002

In reply refer to: A-02-05

Honorable Jane F. Garvey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On March 2, 2002, American Airlines flight 334, a Fokker F.28 Mark 100,[1] experienced an uncontained rupture of the turbine wheel in the AlliedSignal model GTCP36-150RR auxiliary power unit (APU) after deicing fluid entered the APU while the airplane was being deiced at the Dallas-Ft. Worth International Airport, Texas. The interior of the airplane's tailcone sustained damage from the liberated turbine wheel fragments. One fragment of the turbine wheel penetrated the aft pressure bulkhead and became embedded in the first aid kit that is stored directly beneath the flight attendant's aft jump seat in the rear of the airplane's cabin. The event occurred as the airplane was preparing to depart Dallas-Ft. Worth as a scheduled domestic flight to Nashville, Tennessee, in accordance with 14 *Code of Federal Regulations* Part 121. There were no injuries to the passengers and crewmembers.

Generically, APUs are small jet engines equipped with generators and bleed air ports to provide electricity and air to the airplane while it is on the ground. The APU normally operates at 100 percent rpm, but under some circumstances it can quickly accelerate beyond this value, resulting in a hazardous situation. The GTCP36-150RR APU is equipped with an electronic control unit (ECU) that will, among other things, shut down the APU by closing off its supply of fuel if it senses that the speed of the APU rotors is greater than 107 percent rpm. In the F.28 Mark 100, the APU is mounted in the tailcone transversely across the fuselage and directly behind the aft pressure bulkhead. Air for the APU is supplied through an inlet duct on the upper right side of the fuselage just forward of the vertical fin's leading edge.

Examination of the APU by the National Transportation Safety Board at the American Airlines facility in Tulsa, Oklahoma, revealed that the compressor case was ruptured in the plane

[1] The airplane is certificated as the "F.28 Mark 100," but it is commonly called the "F.100."

of the turbine wheel.[2] The turbine wheel was broken into numerous small fragments. The fragments are to undergo a metallurgical examination to determine if fatigue was a factor; however, no evidence of fatigue has been found at this time. Interrogation of the ECU's nonvolatile memory showed that an overspeed had occurred.

On March 6, 2001, an event that was similar to the Dallas-Ft. Worth event occurred on American Airlines flight 581, an F.28 Mark 100, at Dorval International Airport, Montreal, Canada. As in the Dallas-Ft. Worth event, the airplane was being deiced while the APU was operating. The ECU nonvolatile memory showed that the ECU sensed an overspeed and cut off fuel to the APU. However, the rotor continued to accelerate until the turbine wheel burst.

The Type I deicing fluid being used to deice American Airlines flight 334 is an ethylene glycol solution that is combustible when compressed. If deicing fluid enters the APU inlet, it will augment the combustion process. If the APU ingests enough deicing fluid, it will sustain combustion even if the ECU senses an overspeed and cuts off the fuel to the APU. Because the ECU no longer has command of the rotor speed, the APU will continue to accelerate unabated until the turbine wheel bursts.

In February 2001, American Airlines issued a "Winterization Bulletin" for the F.28 Mark 100 airplane, advising that deicing fluid should not be allowed to enter into the APU inlet. Additionally, the F.28 Mark 100 Maintenance Manual, Section 12-31-00, page 301, states, "Do not let de-icing and/or anti-icing fluid/water mixture go into the APU inlet. Injury to persons and/or damage to equipment can occur."

Although its investigation into the event at Dallas-Ft. Worth event is ongoing, the Safety Board is concerned that deicing fluid could inadvertently enter the APU inlet of another F.28 Mark 100, resulting in an uncommanded acceleration of the APU rotors and another turbine wheel rupture. The Board is further concerned that turbine wheel fragments liberated by such an event could penetrate the cabin of the F.28 Mark 100 and injure passengers and crew. The Federal Aviation Administration has advised the Safety Board that the Fokker F.28 Mark 4000 has the same APU and air-inlet configuration as the F.28 Mark 100.

Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

> Immediately issue an airworthiness directive for the Fokker F.28 Mark 100 and F.28 Mark 4000 airplanes that prohibits auxiliary power unit operation during deicing operations. (A-02-05) (URGENT)

[2] The turbine wheel and compressor impeller are mounted back-to-back within the compressor case.

Chairman BLAKEY, Vice Chairman CARMODY, and Members HAMMERSCHMIDT and BLACK concurred in this recommendation. Member GOGLIA disapproved this recommendation and filed the enclosed dissent.

Original Signed

By: Marion Blakey
Chairman

Enclosure

DISSENTING STATEMENT

Notation 7453

Member Goglia, Dissenting;

The safety recommendation to the FAA that an airworthiness directive be issued to prohibit APU operation "during deicing operations" misses the mark. First, it does not address the importance of effective training in deicing and anti-icing applications. We know the critical importance of deicing and anti-icing because there have been numerous accidents related to this activity, the lack of it, or its improper application. Safety would be far better served by a directive that addresses the issue from a broader perspective that holds the prospect of an ongoing higher standard of training for all deicing crews across all fleet types, rather than the correction of a specific shortcoming for a particular aircraft type.

Second, prohibiting the use of the APU during "deicing operations" may have significant unintended consequences.

Again, safety would be better served by having a well-trained deicing crews that are fully trained and comprehend all aspects of this important activity and the consequences of any deviation from approved procedures.

John Goglia, Board Member